APPENDIX - 5
METEOROLOGY

Appendix A - 5.1 Meteorology at NARS

Table A-5.1.1 Mean Daily Temperature at NARS

(Unit: °C)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul																		24.5	29.5	30.2	29.3	25.7	26.5	26.5	25.9	26.0	25.5	26.1	25.6	25.6	25.8	26.6
Aug	22.5	26.4	26.2	25.6	24.9	25.4	25.9	29.7	34.2	34.3	30.5	29.6	31.2	26.3	25.9	26.5	27.0	27.2	26.5	27.5	28.9	29.8	30.0	27.4	29.6	28.0	31.1	28.0	28.8	28.5	26.1	28.0
Sep	27.2	27.9	27.9	28.9	31.7	31.9	31.0	31.0	31.3	30.7	32.2	29.8	27.1	27.3	27.7	29.3	30.6	30.8	27.0	28.2	27.8	29.0	30.1	30.9	30.1	30.4	30.1	31.2	30.2	30.1		29.6
Oct	29.5	28.3	22.3	38.4	35.0	34.0	33.2	NA	36.7	33.9	33.0	33.3	32.6	31.9	33.2	34.1	32.2	33.0	34.1	34.4	33.3	32.9	26.7	29.7	31.4	31.7	NA	NA	NA	NA	31.9	32.3
Nov	28.3	26.9	27.6	27.5	27.5	29.8	29.3	28.2	29.0	25.9	26.6	32.3	27.9	28.3	26.4	28.1	21.4	NA	NA	NA	NA	NA	NA	NA	27.7	24.4	23.7	20.9	22.4	25.0		26.7
Dec	25.5	23.8	25.5	25.6	26.1	25.3	26.0	23.9	25.2	24.4	25.6	20.6	NA	NA	NA	NA	28.3	25.6	24.9	24.9	24.9	25	20.2	22.3	25.1	23.6	21.4	20.9	19.2	NA	NA	24.2
1996																																
Jan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	23.2	19.1	18.1	23.1	26.9	25.9	27.1	27	27	23	24	26	24	22	26	NA	NA	NA	24.2
Feb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24.1	25.9	25.3	25.2	26.3	26.3	26.7	27.5	25.7	23.2	23.6	20	17	16	15	15	NA	23	22			22.7
Mar	23	24.1	24.8	21.8	19.7	20.1	22.8	23.5	23.8	24.1	20.6	20.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22.4
Apr	NA	NA	NA	NA	NA	NA	37.2	33.6	34.1	31.3	33.8	31.0	27.5	NA	NA	NA	NA	NA	NA	NA	24.1	26	27	31	28	26	27	30	26	25		29.3
May	NA	NA	NA	NA	NA	NA	NA	NA	32.8	30.0	25.6	23.9	28.7	NA	27.8	32.0	30.7	NA	NA	NA	31.5	28	29.2	26.7	27.6	27.3	24.3	30.2	35.1	35.9	32.8	29.5
Jun	30.6	29.4	30.8	35.6	34.5	35.5	35.9	35.6	35.9	34.4	22.8	21.1	24.4	25.7	26.6	28.4	28.4	28.7	29.1	28.6	27.3	27.3	27.3	22.8	31.7	27.8	27.8	27.1	27.5	27.5		29.2
Jul	27.7	26.9	26.4	27.8	28.0	27.8	29.1	29.8	29.7	27.5	28.1	26.5	27.3	27.0	27.1	29.5	32.1	32.7	34.8	34.2	34.5	34.0	32.2	31.9	32.4	31.6	30.8	30.2	30.7	29.9	26.5	29.8
Aug	32.5	32.0	31.8	32.8	32.2	30.7	31.0	33.2	34.0	34.3	35.1	34.6	33.8	33.2	33.0	33.2	32.7	32.6	33.9	31.6	31.6	31.3	28.7	27.9	28.5	29.3	31.1	32.4	30.9	32.4	30.7	32.0
Sep	27.8	27.6	28.3	26.8	27.2	28.6	28.9	28.8	29.1	28.7	28.6	31.0	32.3	33.2	33.0	32.8	32.3	32.6	32.6	31.6	31.3	30.7	29.2	28.5	26.8	26.8	28.2	29.6	30.0	28.1		29.7
Oct	28.2	29.1	28.2	28.6	27.7	26.8	26.9	24.2	25.8	25.3	25.4	25.3	25.0	23.5	24.1	25.7	25.1	25.5	26.1	23.9	28.3	26.3	25.3	23.7	23.6	23.2	24.1	24.6	18.0	NA	NA	25.4

Table A-5.1.2 Mean Daily Relative Humidity at NARS

(Unit: %)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul																		61	40	34	43	61	55	52	58	59	62	55	56	57	57	53.5
Aug	69.6	57.3	56.4	59.2	60.2	58.3	59.1	60.6	52.4	52.6	60.0	61.8	53.8	58.6	46.1	56.6	53.6	54.8	57.4	47.5	53.8	42.2	55.5	40.1	45.6	48.8	45.4	48.7	44.5	51.1	49.1	53.6
Sep	40.7	45.3	55.5	58.7	49.8	44.8	48.7	33.6	29.9	39.3	26.5	48.5	61.7	59.2	56.1	48.3	38.8	43.9	53.0	43.6	42.6	43	33.7	28.3	29.9	32.5	30.8	23.0	36.5	32.9		42.0
Oct	34.4	41.5	64.8	23.7	44.8	53.8	58.9	NA	24.8	28.0	45.3	50.4	54.5	54.8	40.4	26.3	24.8	32.1	59.3	51.2	43.9	47.6	46.0	26.2	29.7	33.8	NA	NA	NA	NA	18.4	40.7
Nov	49.0	50.6	43.7	33.6	25.0	29.8	35.5	39.2	49.5	29.2	29.8	28.8	42.0	37.8	39.9	43.8	55.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		39.0
Dec	NA	67.3	51.6	60.0	60.4	57.1	51.2	52.7	59.4	56.5	60.5	75.1	NA	NA	NA	NA	38.0	54.5	56.5	54.3	53.5	57.1	77.4	58.2	58.8	65.0	57.4	46.7	36.1	NA	NA	56.9
1996																																
Jan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.5	36.5	45.2	65.0	65.0	68.5	58.3	NA	NA	50.6	61.6	65.2	61.1	55.5	30.5	NA	NA	NA	53.9
Feb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65.4	57.5	53.6	45.4	45.6	60.4	59.2	65.6	50.5	36.6	49.9	53.6	30.5	28.7	31.1	48.8	61.4	53.8	61.9			50.5
Mar	58.8	52.7	46.4	55.8	57.6	54.9	54.7	57.0	58.3	61.4	57.3	71.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57.2
Apr	NA	NA	NA	NA	NA	NA	NA	20.5	34.3	26.3	33.0	35.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	36	50.0	45.5	35.7	10.2	2.5	NA		30.0
May	NA	NA	NA	NA	NA	NA	NA	33.3	49.1	40.1	51.8	55.1	NA	52.3	51.2	37.3	NA	NA	NA	NA	54.5	53.9	47.0	18.7	20.1	12.0	7.5	46.5	40.0	44.0	NA	39.7
Jun	51.6	61.8	61.3	39.8	47.9	43.8	40.7	43.5	36.9	38.2	87.3	81.4	64.9	55.1	50.8	46.7	45.3	41.5	34.1	33.8	48.8	46.1	50.4	73.0	28.8	45.3	48.6	52.4	51.0	52.8		50.1
Jul	51.8	55.5	52.3	44.2	54.6	58.7	59.8	56.6	57.8	51.5	51.2	56.0	57.3	47.7	50.4	68.8	51.1	52.8	45.4	47.5	50.0	51.3	59.2	63.9	62.0	65.0	65.8	65.9	64.8	55.1	39.6	55.3
Aug	43.8	46.0	46.9	42.5	41.4	53.9	58.7	55.2	54.5	54.1	51.1	53.6	51.3	49.2	48.4	49.0	49.3	48.7	43.9	52.2	54.9	52.8	59.7	64.8	59.0	54.3	60.2	58.4	59.9	56.5	67.6	53.0
Sep	70.2	74.3	59.0	52.0	50.6	43.3	42.1	42.9	42.3	50.2	57.4	42.3	35.8	38.2	50.0	51.6	41.2	31.9	29.9	13.4	6.3	9.4	14.8	37.5	34.8	46.0	47.7	39.7	37.7	42.0		41.2
Oct	46.2	35.9	39.3	36.4	34.9	43.6	51.9	41.8	39.3	63.7	58.8	56.6	62.0	68.2	82.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50.7

Table A-5.1.3 Daily Average Wind Speed at NARS

(Unit: m/s)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul												3.0	3.5	4.9	4.2	4.7	4.1	4.0	5.7	4.9	3.8	5.0	6.9	5.1	8.5	8.4	8.6	8.9	NA	NA	NA	5.5
Aug	9.9	8.1	9.3	9.4	9.0	8.0	8.2	7.5	5.6	6.0	8.7	10.1	7.1	7.2	9.1	7.4	5.3	4.5	5.4	4.2	3.3	3.7	4.4	3.9	3.8	2.8	4.0	4.6	3.8	4.4	6.3	6.3
Sep	5.0	3.8	3.8	3.4	3.5	3.5	4.8	3.3	2.8	3.3	3.1	3.9	4.8	5.1	3.4	3.1	3.8	4.9	5.6	3.5	3.2	4.4	2.3	1.0	1.9	2.9	3.3	2.7	2.7	2.8		3.5
Oct	3.3	3.1	2.8	3.3	3.8	2.9	2.2	2.5	2.7	2.7	2.2	3.5	2.7	2.2	2.1	2.4	NA	NA	NA	NA	NA	5.3	2.5	2.8	2.9	2.8	2.4	3.0	2.6	2.1	2.4	2.8
Nov	3.9	2.6	2.2	1.7	2.5	3.4	2.0	2.3	3.1	1.0	2.1	1.4	2.0	2.1	1.5	1.9	0.9	1.8	1.7	1.4	0.8	1.2	1.1	1.8	1.1	1.7	2.9	1.7	1.5	2.3		1.9
Dec	2.8	2.4	2.9	1.7	1.1	1.3	1.8	1.7	1.9	1.5	2.8	3.6	1.5	0.8	2.0	3.8	2.6	2.2	1.5	3.3	1.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.6	2.1
1996																																
Jan	0.9	2.1	3.2	3.1	3.7	3.1	2.8	3.1	2.5	2.9	4.1	2.4	3.1	1.6	1.0	2.8	4.4	2.8	1.9	1.8	2.2	3.0	5.5	2.1	2.5	3.7	2.8	0.9	1.3	2.3	0.8	2.6
Feb	1.9	3.8	1.9	6.8	2.1	3.1	0.8	1.3	0.8	4.1	2.9	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		2.3
Mar	NA	NA	4.1	7.2	5.2	7.0	7.5	7.2	5.5	4.7	6.7	8.0	5.8	3.9	0.8	1.0	1.5	3.1	6.3	2.9	1.7	6.4	4.9	5.1	4.4	4.5	5.0	2.4	2.9	3.2	1.3	4.5
Apr	2.1	2.3	2.3	3.4	3.4	1.1	4.0	1.8	2.2	3.7	2.6	1.7	4.3	6.6	5.6	3.3	3.1	1.0	3.1	3.5	3.7	2.4	3.2	2.8	1.1	1.7	1.3	0.6	2.0	2.5		2.7
May	1.2	0.2	2.0	3.0	1.1	NA	NA	NA	NA	NA	NA	6.5	5.0	4.6	3.9	3.2	4.7	4.4	4.7	6.3	7.1	5.9	4.5	4.0	4.9	5.5	6.1	4.8	7.3	3.0	3.9	4.3
Jun	4.3	4.3	4.8	5.6	2.7	3.3	4.0	2.7	2.5	2.4	NA	NA	8.3	6.4	5.1	4.1	6.1	4.9	5.4	4.9	2.7	5.1	4.6	5.9	5.8	3.8	NA	NA	NA	NA		4.6
Jul	NA	4.5	3.9	7.5	8.9	9.3	7.6	5.4	5.2	5.7	6.0	5.8	6.1	4.6	7.8	6.2	7.3	6.3	4.0	6.0	7.0	7.8	7.6	NA	NA	NA	NA	NA	NA	NA	6.5	6.4
Aug	8.4	9.0	9.6	9.1	7.4	8.2	10.2	9.7	7.1	8.0	6.1	6.7	5.6	6.3	6.9	5.0	4.7	4.6	4.1	4.4	4.7	4.0	4.3	4.8	4.5	4.3	4.6	3.6	2.7	2.8	3.0	5.9
Sep	3.3	2.7	4.7	5.5	4.5	4.1	4.5	4.5	3.9	4.1	5.0	2.8	2.9	1.9	2.7	3.0	2.3	3.0	2.7	1.8	1.9	2.1	2.6	3.9	3.7	3.3	3.3	3.0	3.3	3.9		3.4
Oct	2.4	3.5																														3.0

Table A-5.1.4 Daily Gust Maximum Wind Speed at NARS

(Unit: m/s)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul												4.0	10.0	12.1	10.8	14.8	9.7	10.2	14.2	10.2	12.5	10.8	13.1	12.5	14.5	14.2	19.0	15.9	NA	NA	NA	12.3
Aug	11.1	15.2	13.9	14.5	15.1	12.9	13.8	15.8	12.2	11.0	14.8	16.5	12.0	14.5	14.2	14.6	9.0	11.4	9.5	8.5	8.3	10.6	9.4	9.3	9.2	8.0	11.2	12.8	9.8	11.2	9.6	11.9
Sep	10.2	9.1	8.8	10.0	7.8	7.2	7.2	8.6	8.2	7.5	9.8	11.4	10.2	10.5	7.8	7.2	12.2	13.8	10.2	10.0	10.2	11.2	7.2	5.2	8.5	7.8	6.5	6.2	7.0	5.5		8.8
Oct	7.6	9.5	9.8	9.8	12.3	8.3	11.2	9.2	8.2	9.5	9.2	10.2	11.0	9.5	12.2	13.8	NA	NA	NA	NA	NA	11.0	9.9	10.1	11.1	12.1	9.3	10.8	9.2	12.7	8.0	10.2
Nov	8.6	8.6	7.0	8.9	11.0	9.8	7.5	11.4	10.0	11.8	8.1	5.5	8.0	9.1	7.7	6.1	4.5	10.9	7.3	7.4	7.8	5.1	3.2	7.8	9.6	8.2	8.1	6.0	4.1	7.8		7.9
Dec	8.5	7.1	9.2	9.2	9.2	7.1	8.0	7.2	8.4	9.7	9.9	10.7	8.3	5.6	7.5	11.9	8.0	7.5	12.0	9.3	9.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.6	8.4
1996																																
Jan	5.8	10.4	9.0	8.3	10.5	11.0	7.3	9.4	10.8	12.7	14.8	9.3	12.2	9.0	7.8	8.7	13.0	11.0	12.0	7.3	8.3	10.5	14.3	8.7	9.5	11.2	9.1	5.0	8.5	8.5	6.3	9.7
Feb	7.4	9.0	9.0	13.0	10.5	10.0	6.5	6.3	6.0	9.5	10.6	11.0	11.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		9.3
Mar	NA	NA	13.9	13.0	12.5	18.0	18.0	15.0	12.8	12.0	13.2	18.0	14.5	9.5	8.5	7.0	9.5	8.0	7.5	11.5	12.5	9.5	13.4	12.2	12.0	10.9	12.5	9.2	12.5	8.0	6.0	11.8
Apr	7.5	10.2	12.5	10.0	7.5	7.2	11.5	9.5	8.2	9.2	8.4	10.0	11.2	12.4	10.5	11.6	11.5	9.6	6.5	11.2	8.9	11.8	12.5	12.0	9.4	7.0	10.8	12.0	9.2	10.6		10.0
May	12.5	10.0	8.5	4.5	13.0	NA	NA	NA	NA	NA	NA	15.0	13.1	12.0	12.5	11.5	13.0	10.6	13.0	13.5	13.8	11.9	11.2	9.8	11.2	10.9	14.4	13.3	12.0	12.0	11.0	11.8
Jun	12.0	12.0	12.3	13.3	6.3	11.1	11.7	10.1	12.3	10.7	11.1	13.6	NA	NA	14.0	13.9	13.0	10.0	14.0	4.9	NA	11.5	17.2	11.8	11.1	10.0	12.7	11.3	15.9	NA		11.8
Jul	NA	10.5	10.4	12.9	15.0	15.4	15.1	12.3	10.3	11.1	11.6	13.4	12.7	11.7	12.5	13.6	14.0	12.6	11.1	14.2	12.8	15.6	NA	NA	NA	NA	NA	NA	NA	NA	14.0	12.9
Aug	14.8	17.2	12.1	15.5	15.4	15.6	16.4	17.6	13.1	13.2	12.9	12.5	11.1	11.5	12.4	11.7	9.9	11.4	9.0	9.6	10.1	9.5	10.1	11.7	9.6	9.2	9.2	9.9	9.2	11.2	9.8	12.0
Sep	9.4	11.2	12.8	11.3	12.5	8.8	9.9	11.0	9.4	11.1	10.0	7.7	9.7	7.6	8.3	8.6	7.7	9.4	10.0	8.1	8.3	8.3	7.2	9.8	11.5	9.0	8.8	6.5	9.0	13.1	3.9	9.4
Oct	7.8	13.4																														10.6

Table A-5.1.5 Mean Daily Solar Radiation at NARS

(Unit: MJ/m^2 day)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.73	21.42	13.37	18.51	20.22	21.42	21.42	17.82	20.22	15.42	12.00	20.39	18.68	17.31	19.36	NA	NA	NA	NA	NA	18.55
Aug	20.73	21.76	20.91	20.56	20.56	20.56	21.76	21.08	20.91	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.98
Sep	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Oct	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.00	17.82	16.79	17.14	16.62	16.28	17.14	16.79	17.48	18.51	16.06
Nov	17.48	17.31	17.14	18.16	16.79	16.45	15.94	15.94	15.94	15.59	15.94	16.11	16.11	15.59	15.08	15.25	15.42	15.42	14.57	17.31	15.59	15.59	16.28	17.99	16.28	15.94	15.42	15.42	15.08	15.08		16.07
Dec	14.57	13.88	15.08	13.88	14.39	15.08	14.57	14.74	14.39	14.39	14.39	14.74	15.08	14.91	14.39	14.22	14.57	15.42	13.19	14.91	15.42	20.22	14.39	14.39	12.17	14.74	17.31	13.54	13.37	13.37	NA	14.66
1996																																
Jan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Mar	NA	NA	NA	18.51	17.99	18.34	18.16	17.65	19.36	18.16	16.11	17.48	14.74	14.22	19.19	19.36	19.36	19.02	19.19	16.45	19.36	20.22	21.25	19.02	19.71	20.05	19.71	19.88	20.39	21.25	20.39	18.73
Apr	21.93	22.11	20.05	20.91	20.91	20.56	20.56	20.91	20.91	21.42	20.91	20.05	21.76	22.11	22.45	23.30	20.22	20.22	22.79	21.42	21.25	23.13	21.76	21.59	22.45	21.93	22.79	20.73	21.08	20.73	NA	21.43
May	22.60	20.70	20.10	22.50	23.30	22.60	23.00	21.30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.45	21.93	21.08	22.79	NA	NA	NA	NA	21.76	22.28	21.59	21.20
Jun	22.11	24.16	21.08	22.11	21.59	22.62	21.42	20.39	24.33	17.31	23.08	20.39	19.54	21.59	21.42	21.08	20.73	18.34	19.02	21.93	20.39	20.39	19.36	21.25	20.73	21.42	21.25	20.91	20.91	21.93		21.09
Jul	21.93	20.73	21.08	20.91	11.14	19.02	20.05	20.91	21.08	19.71	19.71	19.71	19.02	19.19	19.71	17.99	19.71	20.56	19.88	20.56	18.16	17.99	16.62	19.54	19.19	19.19	17.82	17.99	20.05	8.40	16.11	18.83
Aug	18.05	20.29	20.46	18.40	19.08	15.99	20.80	19.26	19.77	20.46	21.15	21.49	20.29	19.26	19.26	21.49	20.12	19.77	19.77	20.98	20.63	20.29	20.46	22.35	22.01	19.94	23.90	17.54	23.21	22.35	21.84	20.34
Sep	21.32	22.87	22.01	23.90	19.94	19.08	21.32	19.94	20.29	20.29	20.12	19.94	19.94	19.26	21.15	21.84	19.43	21.15	19.77	20.80	19.77	19.08	20.63	20.46	19.77	20.98	17.36	18.74	18.74	20.46		20.35
Oct	22.69	17.17	18.74	20.12	17.02	18.91	19.94	18.74	18.57	20.12	18.91	18.40	17.88	18.91	19.26	18.74	17.54	17.71	17.88	18.22	17.19	16.85	17.54	18.74	17.71	18.57	18.57	19.60	NA	NA	NA	18.58

Table A-5.1.6 Mean Daily Sunshine Duration at NARS

(Unit: hours)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12.0	11.9	12.0	12.0	11.9	12.0	12.0	12.2	12.0	12.0	12.2	12.1	12.2	12.2	12.2	NA	NA	NA	NA	NA	12.1
Aug	12.2	12.2	12.0	12.3	12.4	12.3	12.0	12.0	12.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12.2
Sep	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Oct	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11.2	10.8	10.9	11.3	11.0	10.9	11.0	11.2	11.0	11.0
Nov	11.2	11.2	11.2	11.0	10.4	11.0	11.0	11.0	11.0	10.8	10.8	11.0	10.6	10.6	10.6	10.6	11.0	10.8	11.0	10.8	10.8	10.8	10.8	10.8	11.2	10.8	10.2	10.6	10.8	10.4	NA	10.8
Dec	10.6	10.6	10.4	10.6	10.8	10.8	11.0	10.6	10.6	10.6	10.8	10.8	10.6	10.8	10.6	10.4	10.4	10.4	10.4	10.8	10.6	10.6	11.0	10.8	10.8	10.6	10.4	10.9	10.8	10.4	NA	10.7
1996																																
Jan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			NA
Mar	NA	NA	5.8	11.4	11.4	11.2	11.4	11.2	11.4	11.4	11.2	11.2	11.2	11.2	11.4	11.6	11.6	11.4	11.4	11.4	11.6	11.7	11.8	11.8	11.4	11.6	11.8	11.7	11.8	11.8	11.9	11.3
Apr	11.5	11.6	11.8	11.9	11.9	11.8	12.0	11.9	11.9	12.0	11.8	12.0	11.9	12.0	12.0	11.9	12.0	12.0	12.2	12.0	12.0	12.2	12.1	12.2	12.2	12.2	12.3	12.0	12.2	12.4	NA	12.0
May	12.2	12.2	12.0	12.3	12.4	12.3	12.0	11.2	11.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.3	12.2	12.6	12.6	NA	NA	NA	NA	12.4	12.6	12.6	11.8
Jun	12.8	12.7	12.8	12.6	12.6	12.8	12.8	12.6	12.6	12.7	10.0	11.8	12.6	12.6	12.6	12.6	12.4	12.6	12.4	12.6	12.6	12.4	12.6	12.8	12.8	12.3	12.8	12.7	12.8	12.4		12.5
Jul	12.4	12.4	12.8	12.6	12.4	12.6	12.6	12.6	12.4	12.4	12.4	12.4	12.0	12.4	12.4	12.8	12.4	12.4	12.4	12.2	12.2	12.0	11.6	11.8	12.2	12.0	12.2	12.2	12.0	11.0	12.0	12.3
Aug	12.0	12.2	12.2	12.2	12.2	14.2	12.2	12.2	12.4	12.2	12.4	12.4	12.2	12.2	12.4	12.2	12.0	12.4	12.0	12.4	12.2	12.4	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.0	12.3
Sep	12.0	12.0	12.0	12.0	11.6	11.6	11.8	11.6	11.6	11.6	11.8	12.0	12.0	11.6	11.6	11.6	11.8	11.8	11.6	11.6	11.6	11.2	11.4	11.5	11.5	11.6	11.4	11.4	11.4	11.5		11.7
Oct	12.0	11.6	11.6	11.6	11.6	11.6	11.5	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.6	11.2	11.6	11.3	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.0	NA	NA	NA	11.4

Appendix A - 5.2 Meteorology in South Oman

Table A-5.2.1 Climatological Condition at Salalah

Altitute : 21.78 m Lat. : 17.03 N Lon. : 54.08 E

Descritions	unit	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean	Max.	Min.
Temperature																	
Mean-Mean	C.D	23.0	24.1	25.9	27.9	29.4	29.4	26.4	25.2	26.3	26.7	26.2	24.4	---	26.2	29.4	23.0
Mean-Max.	C.D	26.3	27.2	29.3	30.9	31.6	33.0	29.1	27.7	28.8	30.3	30.6	28.9	---	29.5	33.0	26.3
Mean-Min.	C.D	19.2	20.8	22.6	24.9	27.0	27.2	24.4	23.4	23.7	22.9	22.2	19.7	---	23.2	27.2	19.2
Extream-Max.	C.D	32.3	33.8	36.7	43.6	42.3	44.7	33.0	31.0	32.2	40.1	37.4	34.2	---	36.8	44.7	31.0
Extream-Min.	C.D	11.0	15.0	18.0	21.3	24.0	22.0	21.0	19.4	16.5	16.0	14.1	17.6	---	18.0	24.0	11.0
Relative Humidity																	
Mean-Mean	%	52.5	56.8	62.2	69.1	75.2	80.4	88.4	90.0	80.8	66.5	54.9	52.8	---	69.1	90.0	52.5
Mean-Max.	%	73.7	77.9	79.0	80.9	82.9	88.9	95.8	97.2	93.0	81.8	71.2	73.7	---	83.0	97.2	71.2
Mean-Min.	%	19.2	18.0	28.4	41.6	61.3	63.4	75.1	79.9	65.8	40.5	27.1	23.4	---	45.3	79.9	18.0
Extream-Max.	%	95.0	98.0	97.0	99.0	99.0	99.0	100.0	100.0	100.0	98.0	90.0	98.0	---	97.8	100.0	90.0
Extream-Min.	%	1.0	4.0	5.0	5.0	6.0	4.0	10.0	58.0	24.0	7.0	6.0	6.0	---	11.3	58.0	1.0
Wind																	
Prevailing Direction	Deg	171.6	189.0	185.5	191.9	199.9	202.8	191.2	195.1	195.3	189.0	154.5	91.5	---	179.8	202.8	91.5
Speed, Mean	Knot	6.3	6.0	5.5	5.8	6.1	7.7	5.8	5.5	5.7	4.6	4.5	6.2	---	5.8	7.7	4.5
	m/sec	2.8	2.7	2.5	2.6	2.7	3.4	2.6	2.5	2.5	2.1	2.0	2.8				
Speed, Max. Gust	Knot	35.2	32.3	29.5	24.7	23.1	23.5	20.9	20.7	23.1	20.4	25.5	31.5	---	25.9	35.2	20.4
	m/sec	15.7	14.4	13.2	11.0	10.3	10.5	9.4	9.3	10.3	9.1	11.4	14.1				
Precipitation																	
Monthly Total	mm	3.9	14.4	4.4	20.5	3.6	5.5	26.4	28.9	4.9	0.0	0.3	1.3	---	9.5	28.9	0.0
Maximum 24 hr.	mm	---	---	---	---	---	---	---	---	---	---	---	---	---		0.0	0.0
Evaporation (PI CHE's)																	
Mean	ml/d	11.7	9.5	8.4	6.9	6.6	4.8	2.3	1.9	4.0	6.3	9.0	11.5	---	6.9	11.7	1.9
Max	ml/d	30.7	28.9	27.3	16.8	9.8	8.6	4.6	3.7	6.5	11.5	17.8	26.7	---	16.1	30.7	3.7
Min	ml/d	4.0	3.7	4.1	3.7	4.2	2.4	0.7	0.4	1.5	4.0	4.9	4.3	---	3.2	4.9	0.4
Station Level Pressure																	
Mean	hPa	1014.7	1013.2	1011.2	1009.1	1006.5	1002.1	1001.8	1002.4	1005.9	1010.5	1012.9	1014.7	---	1008.7	1014.7	1001.8
Max	hPa	1020.0	1018.4	1016.6	1014.2	1011.3	1007.1	1005.9	1006.6	1011.3	1015.3	1017.6	1019.3	---	1013.6	1020.0	1005.9
Min	hPa	1009.5	1008.1	1005.9	1004.2	1000.8	997.0	996.8	998.0	1000.1	1005.0	1007.4	1009.7	---	1003.5	1009.7	996.8
Vapor Pressure																	
Mean	hPa	15.3	16.9	20.5	25.7	30.4	32.6	30.1	28.7	27.4	23.5	18.7	16.6	---	23.9	32.6	15.3
Max	hPa	25.3	26.2	28.4	33.2	36.3	37.1	34.4	32.0	31.6	30.5	29.1	26.7	---	30.9	37.1	25.3
Min	hPa	2.9	2.5	3.6	8.1	12.7	21.3	23.3	25.0	21.3	10.4	6.6	7.4	---	12.1	25.0	2.5
Sun Shine Hours																	
Mean	hr.	9.4	9.1	9.6	10.0	10.8	6.6	1.6	1.5	5.7	10.1	10.1	9.6		7.8	10.8	1.5
Max	hr.	10.5	10.8	10.9	11.8	12.0	11.2	7.0	6.9	10.3	11.0	10.8	10.3		10.3	12.0	6.9
Min	hr.	4.4	3.7	3.5	4.5	7.7	0.1	0.0	0.0	0.0	7.1	5.4	5.1		3.5	7.7	0.0

Table A-5.2.2 Climatological Condition at Thumrait

Altitute : 448.0m, Lat. : 17 40N Lon. : 54 02E

Descritions	unit	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean	Max.	Min.
Temperature																	
Mean-Mean	C.D	18.6	21.1	24.6	28.1	31.1	32.2	29.6	29.5	29.0	26.7	23.2	19.9	---	26.1	32.2	18.6
Mean-Max.	C.D	25.0	27.3	31.4	34.7	38.3	39.2	36.6	37.3	36.1	33.8	29.0	25.4	---	32.8	39.2	25.0
Mean-Min.	C.D	11.2	14.5	18.1	16.5	20.8	24.9	24.6	23.8	22.7	19.8	16.5	13.1	---	18.9	24.9	11.2
Extream-Max.	C.D	33.2	35.0	38.6	41.0	43.8	45.0	45.0	46.0	43.8	40.0	34.4	33.0	---	39.9	46.0	33.0
Extream-Min.	C.D	6.0	8.7	13.2	16.6	19.4	21.0	19.0	17.0	12.0	9.0	5.0	13.8	---	13.4	21.0	5.0
Relative Humidity																	
Mean-Mean	%	53.2	51.1	45.6	41.4	42.4	45.5	59.8	57.1	49.5	40.4	46.2	53.8	---	48.8	59.8	40.4
Mean-Max.	%	72.5	73.6	67.2	63.6	62.7	66.1	74.0	72.3	70.2	62.6	67.3	72.4	---	68.7	74.0	62.6
Mean-Min.	%	30.4	27.0	21.7	20.5	17.3	15.8	34.2	29.7	22.8	17.9	25.5	32.4	---	24.6	34.2	15.8
Extream-Max.	%	100.0	100.0	100.0	100.0	97.0	98.0	100.0	98.0	96.0	95.0	100.0	100.0	---	98.7	100.0	95.0
Extream-Min.	%	4.2	3.3	2.0	2.0	4.0	1.0	3.0	3.0	4.0	2.0	4.0	12.0	---	3.7	12.0	1.0
Wind																	
Prevailing Direction	Deg.	150.0	150.0	162.9	171.4	180.0	180.0	180.0	171.4	162.9	175.7	98.6	120.0	---	158.6	180.0	98.6
Speed, Mean	Knot	7.3	10.0	11.7	11.1	12.1	13.6	20.0	17.4	12.0	8.6	6.4	7.1	---	11.5	20.0	6.4
	m/sec	3.3	4.5	5.2	5.0	5.4	6.1	9.0	7.8	5.4	3.9	2.9	3.2				
Speed, Max. Gust	Knot	27.8	34.7	38.1	33.6	31.6	34.8	38.5	40.1	31.2	29.4	25.2	25.3	---	32.5	40.1	25.2
	m/sec	12.4	15.5	17.1	15.0	14.1	15.5	17.2	17.9	14.0	13.1	11.2	11.3				
Precipitation																	
Monthly Total	mm	0.5	6.4	19.5	15.8	0.0	8.7	0.0	5.0	0.0	0.2	0.0	0.4	---	4.7	19.5	0.0
Maxmum 24 hr.	mm	0.4	2.6	26.5	12.9	0.0	12.9	0.0	1.9	0.0	0.3	0.0	0.5	---	4.8	26.5	0.0
Evaporation (PI CHE's)																	
Mean	ml/d	8.7	10.9	14.9	17.2	19.5	19.1	15.8	16.0	15.7	16.0	11.8	8.9	---	14.5	19.5	8.7
Max	ml/d	12.9	16.8	24.4	24.5	26.9	29.0	22.8	24.0	23.6	23.1	17.8	12.3	---	21.5	29.0	12.3
Min	ml/d	5.1	5.5	7.9	9.2	13.0	11.5	11.3	10.9	9.7	9.5	7.4	5.7	---	8.9	13.0	5.1
Station Level Pressure																	
Mean	hPa	966.5	964.6	962.4	960.5	957.5	952.8	950.8	951.7	956.3	961.8	965.1	966.6	---	959.7	966.6	950.8
Max	hPa	973.5	971.9	969.6	966.4	962.8	958.1	955.3	956.7	962.4	967.5	970.1	972.7	---	965.6	973.5	955.3
Min	hPa	959.8	958.3	956.0	955.0	951.8	948.1	946.4	947.3	950.9	955.9	960.5	960.9	---	954.2	960.9	946.4
Vapor Pressure																	
Mean	hPa	11.1	12.1	12.6	13.9	16.5	18.5	22.4	20.9	17.3	12.5	12.0	12.3	---	15.2	22.4	11.1
Max	hPa	19.7	20.9	23.1	25.6	28.6	30.2	28.2	27.8	26.4	23.8	21.5	20.6	---	24.7	30.2	19.7
Min	hPa	3.6	3.1	3.1	3.9	4.0	2.7	6.1	6.2	4.6	2.9	4.6	4.8	---	4.1	6.2	2.7

Table A-5.2.3 Mean Daily Temperature at Dauka

(Unit: °C)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Jul																		41.9	37.6	38.1	38.8	NA	NA	NA	NA	34.6	34.4	33.8	33.4	33.7	33.7	36.0
Aug	33.0	33.7	33.3	31.3	32.0	33.1	33.8	34.2	36.0	36.4	32.4	31.4	33.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	42.0	37.2	35.5	35.6	37.5	37.5	36.2	37.7	35.7	34.9
Sep	37.4	36.9	37.9	38.2	35.6	35.8	35.3	34.9	36.0	35.3	36.9	32.1	29.5	30.2	31.2	32.5	35.3	35.3	34.8	30.7	30.4	31.7	34.7	34.8	33.6	34.4	33.7	NA	NA	NA		34.3
Oct				37.8	33.2	34.4	33.3	31.4	30.9	31.5	29.7	29.6	28.6	28.1	25.0	NA	NA	33.0	30.7	30.9	30.4	30.5	28.0	28.3	28.3	28.1	28.6	28.3	24.6	26.0	25.4	29.8
Nov	25.1	24.9	24.8	25.3	31.9	27.8	26.3	25.5	25.6	25.2	26.2	20.7	25.5	25.1	25.2	25.1	25.4	24.8	20.3	24.4	24.0	24	23.0	22.6	22.4	22.3	21.0	19.0	20.7	22.6		24.2
Dec	22.6	22.8	23.9	23.4	25.3	27.8	29.6	28.6	27.5	27.2	28.3	28.5	29.4	29.6	29.8	29.0	25.0	23.3	22.1	22.5	22.2	23	23.4	23.4	23.7	23.8	20.3	20.4	20.0	18.6	20.6	24.7
1996																																
Jan	18.6	21.8	21.9	22.0	21.6	20.9	18.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	23	22	22	22	22	22	22	19	20	20	21.1
Feb	20.8	21.5	14.9	NA	NA	NA	NA	NA	NA	NA	NA	22.5	22.3	22.5	10.9	19.5	19.5	21.8	22.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			19.9
Mar	NA	NA	35.9	31.7	32.5	33.9	32.2	32.7	32.0	35.2	33.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	33.3
Apr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	43.6	37.3	34.6	35.9	37.2	36.8	38.3	39.1	38.0	39	41	36	NA	NA	NA	NA	NA	NA			38.1
May	32.0	37.2	37.3	38.2	40.2	38.8	38.4	43.0	39.4	39.7	39.0	39.0	39.9	42.5	42.0	42.1	41.9	40.4	40.8	40.8	39.7	40	39.7	40.1	40.5	40.8	40.2	37.8	34.9	36.1	33.8	39.2
Jun	31.1	32.0	31.8	33.1	33.1	33.6	34.6	34.4	34.8	33.3	24.9	26.1	29.6	31.3	32.5	34.4	37.1	35.6	35.5	35.4	34.2	34.5	34.1	28.6	37.2	33.0	33.6	33.8	33.8	34.3		33.0
Jul	34.8	34.0	33.3	34.5	34.3	34.6	34.1	33.9	35.9	38.7	40.2	40.0	40.8	42.2	41.7	38.1	32.5	33.4	35.0	35.8	36.0	35.3	33.8	32.0	32.8	32.9	32.0	31.3	31.7	27.6	NA	35.1
Aug	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.9	33.4	34.2	33.7	33.0	32.9	33.9	33.3	33.4	32.9	31.0	30.5	31.3	31.9	33.1	31.5	29.7	31.7	29.5	32.6
Sep	27.3	27.6	28.2	27.8	28.6	30.2	30.7	30.4	30.3	30.0	29.9	31.8	33.0	33.2	33.6	33.6	33.8	34.5	33.9	33.4	32.7	31.5	30.3	28.7	28.4	27.4	29.4	30.9	31.1	28.8		30.7
Oct	28.7	30.9	29.5	30.2	30.3	28.1	28.3	26.4	25.7	26.3	26.1	26.9	26.4	25.1	19.8																	27.2

Table A-5.2.4 Mean Daily Relative Humidity at Dauka

(Unit: %)

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
1995																																
Aug	42.5	48.3	49.1	51.8	51.7	50.1	59.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	13.2	34.0	40.5	33.5	32.7	34.1	34.6	41.1
Sep	NA	NA	NA	18.3	31.9	27.5	30.8	18.8	14.4	19.4	12.0	43.6	40.9	49.9	42.9	40.7	29.0	21.5	22.2	17.1	34.8	50	36.3	22.6	22.5	25.2	24.7	7.3	NA	NA		28.2
Oct	NA	NA	NA	NA	5.0	28.3	21.3	7.8	14.4	17.6	17.7	NA	NA	NA	NA	NA	17.3	28.4	33.2	42.6	36.7	20.2	15.1	NA	NA	NA	NA	NA	NA	NA	NA	21.8
Nov	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22.2	17.6	18.2	19.0	37.0	20.1	17.2	60.2	13.4	21.5	18.0	18.5	36.5	13.6	25.7	27.9	27.4	29.0	31.5		25.0
Dec	35.5	34.3	38.1	47.7	43.6	30.0	45.8	38.4	42.6	41.7	44.8	38.3	39.6	45.7	44.1	46.5	38.4	39.3	44.5	36.6	38.2	36.9	43.9	43.8	44.2	42.8	49.3	35.1	23.4	36.4	22.6	39.7
1996																																
Jan	29.6	32.9	36.3	44.6	36.9	44.8	69.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22.0	32.0	33.0	31.3	42	40	46	26	25	29	18	35.5
Feb	12.4	27.7	72.0	NA	NA	NA	NA	NA	NA	NA	NA	41.0	44.3	37.0	22.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		36.7
Mar	NA	NA	29.3	34.4	40.9	36.2	32.3	40.4	44.0	45.8	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.9
Apr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24.6	46.6	36.6	38.0	32.3	39.9	33.8	32.0	37.8	38	33	NA	NA	NA	NA	NA	NA	NA		35.7
May	NA	1.8	27.7	44.5	34.2	36.5	34.1	27.0	40.6	36.9	35.8	41.3	37.4	29.2	31.8	36.9	27.8	31.3	32.6	36.9	37.8	36.3	38.1	31.3	35.1	36.4	39.4	35.6	42.5	41.0	53.1	35.0
Jun	68.0	67.9	61.7	40.5	54.5	52.3	51.3	50.5	50.0	57.3	87.0	86.5	74.0	65.4	60.6	55.8	50.9	52.8	46.3	33.9	54.5	47.4	54.5	77.5	30.9	46.1	52.1	56.4	57.2	58.3		56.7
Jul	55.6	60.9	58.5	50.1	54.8	60.0	62.7	60.4	61.6	53.6	53.9	59.5	58.3	48.3	52.5	58.6	63.6	60.9	53.0	53.9	56.5	58.6	65.9	68.1	64.7	65.1	67.6	68.0	66.9	83.0	NA	60.2
Aug	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	23.4	36.5	36.1	35.8	38.0	37.4	33.8	37.3	39.4	39.0	45.1	47.1	43.2	40.0	38.8	41.8	45.8	37.7	52.6	39.4
Sep	58.8	55.6	43.0	35.5	34.5	28.0	27.4	27.6	25.8	26.3	29.0	22.4	15.4	20.9	24.6	27.5	19.8	15.0	28.4	7.7	12.1	13	17.4	32.6	32.9	34.6	33.0	29.8	26.8	36.5		28.1
Oct	34.0	19.1	24.8	22.2	19.5	31.8	30.3	30.9	35.8	47.4	50.1	41.8	47.2	51.6	45.2	33.1	22.5	20.9	22.9	31.1	46.2	49.2	45.6	39.3	37.6	33.9	32.0	33.0	NA	NA		35.0

Table A-5.3.1 Mean Monthly Temperature (°C) at NARS and other selected locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
NARS															
1995							26.6	28.0	29.6	32.3	26.8	24.2	27.9	32.3	24.2
1996	24.2	22.7	22.4	29.3	29.5	29.2	29.8	32.0	29.7	25.4			27.4	32.0	22.4
Dauka															
1995							36.0	34.9	34.3	29.8	24.2	24.7	30.7	36.0	24.2
1996	21.1	19.9	33.3	38.1	39.2	33.0	35.1	32.6	30.7	27.2			31.0	39.2	19.9
Salalah															
1995	23.3	24.1	25.9	27.9	29.4	29.4	26.4	25.2	26.3	26.7	26.2	24.4	26.3	29.4	23.3
1996	24.0	24.1	26.9	28.1	29.5	29.0	25.7	23.8	25.9				26.3	29.5	23.8
16 year average	23.0	24.1	25.9	27.9	29.4	29.4	26.4	25.2	26.3	26.7	26.2	24.4	26.2	29.4	23.0
Thumrait															
1995	19.2	21.6	23.6	27.1	30.9	32.1	31.2	29.1	29.6	27.3	22.7	20.8	26.3	32.1	19.2
1996	20.3	21.1	24.6	28.1	29.3	29.4	28.0	26.9	28.6				26.3	29.4	20.3
16 year average	18.6	21.1	24.6	28.1	31.1	32.2	29.6	29.5	29.0	26.7	23.2	19.9	26.1	32.2	18.6

Table A-5.3.2 Mean Monthly Relative Humidity (%) at NARS and other selected locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
NARS															
1995							53.5	53.6	42.0	40.7	39.0	56.9	47.6	56.9	39.0
1996	53.9	50.5	57.2	30.0	39.7	50.1	55.3	41.2	50.7				47.6	57.2	30.0
Dauka															
1995								41.1	28.2	21.8	25.0	39.7	31.2	41.1	21.8
1996	35.5	36.7	37.9	35.7	35.0	56.7	60.2	39.4	28.1	35.0			40.0	60.2	28.1
Salalah															
1995	53.7	60.8	62.8	65.4	74.3	82.7	88.4	93.3	82.3	67.0	52.5	63.6	70.6	93.3	52.5
1996	61.7	59.0	68.5	68.1	76.5	85.6	91.9	93.0	83.2				76.4	93.0	59.0
16 year average	52.5	56.8	62.2	69.1	75.2	80.4	88.4	90.0	80.8	66.5	54.9	52.8	69.1	90.0	52.5
Thumrait															
1995	46.4	47.6	50.8	44.1	30.7	39.8	45.3	59.3	42.2	39.7	38.2	59.9	45.3	59.9	30.7
1995	54.9	48.3	54.7	37.0	51.1	60.6	63.3	61.7	47.7				53.3	63.3	37.0
16 year average	53.2	51.1	45.6	41.4	42.4	45.5	59.8	57.1	49.5	40.4	46.2	53.8	48.8	59.8	40.4

Table A-5.3.3 Monthly Average Wind Speed (m/s) at NARS and other selected locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
NARS															
1995							5.5	6.3	3.5	2.8	1.9	2.1	3.7	6.3	1.9
1996	2.6	2.3	4.5	2.7	4.3	4.6	6.4	5.9	3.4	3.0			4.0	6.4	2.3
Salalah															
1995	3.2	2.9	2.7	3.1	2.9	3.5	3.2	2.7	3.0	2.4	2.5	2.5	2.9	3.5	2.4
1996	3.0	2.6	3.2	2.8	3.8	3.8	3.0	2.5	2.7				3.0	3.8	2.5
16 year average	3.2	3.1	2.8	3.0	3.1	4.0	3.0	2.8	2.9	2.4	2.3	3.2	3.0	4.0	2.3
Thumrait															
1995	3.0	5.1	4.9	6.0	5.4	7.0	8.3	9.6	5.6	4.3	3.1	4.5	5.6	9.6	3.0
1996	3.3	5.5	7.2	5.7	8.4	7.8	11.5	9.9	6.0				7.3	11.5	3.3
16 year average	3.8	5.1	6.0	5.7	6.2	7.0	10.3	9.0	6.2	4.4	3.3	3.7	5.9	10.3	3.3

Table A-5.3.4 Monthly Gust Maximum Wind Speed (m/s) at NARS and other selected locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
NARS															
1995							19.0	16.5	13.8	13.8	11.8	12.0	14.5	19.0	11.8
1996	14.8	13.0	18.0	12.5	15.0	17.2	15.6	17.6	13.1	13.4			15.0	18.0	12.5
Salalah															
1995	14.4	15.9	15.9	12.9	11.3	14.4	10.8	13.4	9.3	10.3	10.3	17.5	13.0	17.5	9.3
1996	15.9	15.4	13.9	11.3	14.4	12.3	10.8	9.3	10.3				12.6	15.9	9.3
16 year average	18.1	16.6	15.2	12.7	11.9	12.1	10.8	10.6	11.9	10.5	13.1	16.2	13.3	18.1	10.5
Thumrait															
1995	12.3	14.4	16.5	17.5	15.4	16.5	18.5	19.0	13.9	14.4	10.8	14.9	15.3	19.0	10.8
1996	17.5	17.0	22.6	14.4	15.9	15.9	20.6	20.6	15.9				17.8	22.6	14.4
16 year average	14.3	17.9	19.6	17.3	16.3	17.9	19.8	20.6	16.1	15.1	13.0	13.0	16.7	20.6	13.0

Table A-5.3.5 Prevailing Wind Direction at NARS and other Selected Locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
NARS													
1995							S	S	S	ENE	NE	SE	S
1996	E	E	S	S	S	S	S	S	S	ENE			S
Salalah													
1995	S	S	S	SSE	SSE	SSE	ESE	SE	S	SSE	S	S	S
1996	SSE	SSE	SSE	SSE	S	S	SSE	SSE	SSE				SSE
16 year average	S	S	S	SSW	SSW	SSW	S	SSW	SSW	SSE	S	E	S, SSW
Thumrait													
1995	SSE	S	SSE	SSE	SSE	S	SSW	SSE	SSE	SE	SSE	SSE	SSE
1996	ESE	S	SSE	SSE	SSE	S	SSE	SSE	SSE	SSE			SSE
16 year average	SSE	SSE	SSE	S	S	S	S	S	SSE	S	E	ESE	S

Table A-5.3.6 Daily Mean Solar Radiation (MJ/m^2 day) at NARS

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
1995							18.55	20.98	NA	16.06	16.07	14.66	17.26	20.98	14.66
1996	NA	NA	18.73	21.43	21.20	21.09	18.83	20.31	20.35	18.58			20.07	21.43	18.58

Table A-5.3.7 Daily Mean Sunshine Duration (hrs) at NARS

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min
1995							12.1	12.2	NA	11.0	10.8	10.7	11.4	12.2	10.7
1996	NA	NA	11.3	12.0	11.8	12.5	12.3	12.3	11.7	11.4			11.9	12.5	11.3

Table A-5.3.8 Daily Evaporation Rate (mm/day) measured at NARS and other selected locations in the Nejd Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Max	Min	Annual
NARS																
1995										10.5	6.9	5.4	7.6	10.5	5.4	
1996	6.4	7.0	10.0	13.6	14.1	12.3	13.1	14.2	11.9	10.5			11.3	14.2	6.4	3828.7
Salalah																
1995	13.6	11.7	9.8	9.1	7.1	5.0	13.6	1.6	4.2	7.0	10.9	8.2	8.5	13.6	1.6	3096.4
1996	10.0	8.8	8.1	7.8	6.2	4.1	2.1	1.5	3.8				5.9	10.0	1.5	2137.3
16 year average	11.7	9.5	8.4	6.9	6.6	4.8	2.3	1.9	4.0	6.3	9.0	11.5	6.9	11.7	1.9	2521.5
Thumrait																
1995	8.9	11.2	106.0	13.6	19.2	18.7	16.9	12.9	15.4	15.4	11.4	7.9	21.5	106.0	7.9	4930.5
1996	8.2	10.0	11.4	17.3	14.5	12.0	12.8	11.6	14.8				12.5	17.3	8.2	4566.6
16 year average	8.7	10.9	14.9	17.2	19.5	19.1	15.8	16.0	15.7	16.0	11.8	8.9	14.5	19.5	8.7	5307.7

Note: Evaporation rate was measured using Class A Evaporation pan at NARS and Pitchy Method in Salalah and Thumrait

APPENDIX - 6
WATER USE

Appendix A - 6.1 Groundwater Consumption at NARS

Table A - 6.1(1) Record of Groundwater Consumption (from NJD2 & NJD4 - 1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	272	221	184	0	365	389	197
2	0	0	0	0	0	262	160	196	0	362	249	212
3	0	0	0	0	0	234	0	205	0	350	280	253
4	0	0	0	0	0	337	212	260	310	415	155	256
5	0	0	0	0	0	190	206	271	674	372	84	223
6	0	0	0	0	0	0	220	214	254	329	160	285
7	0	0	0	0	0	0	205	152	431	0	215	279
8	0	0	0	0	0	0	223	180	242	0	326	349
9	0	0	0	0	0	260	163	199	599	362	101	248
10	0	0	0	0	0	349	189	151	230	707	89	205
11	0	0	0	0	0	459	191	199	243	219	96	180
12	0	0	0	0	0	477	373	152	222	192	247	237
13	0	0	0	0	0	320	0	160	234	365	228	200
14	0	0	0	0	0	225	200	204	272	355	218	298
15	0	0	0	0	0	359	218	216	309	370	194	192
16	0	0	0	0	248	446	111	144	0	432	266	259
17	0	0	0	0	264	0	65	213	238	279	314	319
18	0	0	0	0	370	269	19	389	676	333	336	266
19	0	0	0	0	314	0	305	402	333	328	383	189
20	0	0	0	0	370	197	249	323	336	331	338	263
21	0	0	0	0	267	200	264	323	284	319	382	260
22	0	0	0	0	434	192	230	512	358	372	338	197
23	0	0	0	0	417	217	109	505	386	272	337	256
24	0	0	0	0	375	199	246	417	366	323	325	265
25	0	0	0	0	469	210	196	350	282	391	268	191
26	0	0	0	0	490	196	246	462	288	337	304	212
27	0	0	0	0	265	180	260	482	0	295	251	380
28	0	0	0	0	326	167	0	307	310	357	238	205
29	0	0	0	0	354	219	0	382	531	311	312	235
30	0	0	0	0	333	166	0	144	359	232	257	252
31	0	0	0	0	316	0	0	0	0	288	0	202
m3/Mon	0	0	0	0	5,632	6,602	5,081	8,298	8,747	9,983	7,674	7,563
m3/d	0.0	0.0	0.0	0.0	181.7	220.1	163.9	267.7	291.6	321.4	255.8	244.0

Table A - 6.1(2) Record of Groundwater Consumption (from NJD2 & NJD4 - 1996)

unit: x 10 m3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	230	122	268	252	0	0	0	377	153	0	0
2	0	220	189	270	289	0	0	351	383	238	0	0
3	0	237	117	220	241	302	336	0	363	293	0	0
4	0	158	143	306	195	265	0	0	366	434	0	0
5	0	401	19	245	227	270	0	345	372	305	0	0
6	88	349	226	272	159	0	324	411	334	172	0	0
7	302	221	248	254	287	426	111	367	422	415	0	0
8	225	248	215	274	294	0	0	415	341	204	0	0
9	322	0	310	251	150	23	401	368	344	216	0	0
10	267	254	176	303	214	0	0	395	365	286	0	0
11	184	205	411	251	218	0	0	361	456	275	0	0
12	271	268	273	267	163	0	327	423	334	334	0	0
13	262	201	248	253	220	0	112	329	381	245	0	0
14	254	266	197	295	234	0	0	409	317	230	0	0
15	262	235	0	260	256	378	229	384	382	273	0	0
16	233	248	301	258	285	361	0	415	397	0	0	0
17	237	251	303	251	284	0	0	366	384	0	0	0
18	212	274	250	299	279	0	380	389	293	0	0	0
19	262	196	308	249	279	0	0	401	499	0	0	0
20	216	240	212	279	282	0	0	357	294	0	0	0
21	231	232	281	265	228	361	223	369	159	0	0	0
22	205	244	222	281	280	51	79	402	211	0	0	0
23	274	198	310	242	282	0	0	68	260	0	0	0
24	202	250	243	297	276	348	188	410	199	0	0	0
25	251	196	307	288	211	0	0	665	243	0	0	0
26	197	0	235	242	280	95	0	417	328	0	0	0
27	255	121	275	279	288	320	0	375	284	0	0	0
28	210	141	252	265	47	508	0	393	231	0	0	0
29	257	89	307	264	0	0	0	366	234	0	0	0
30	267	0	231	255	32	0	303	333	280	0	0	0
31	264	0	281	0	61	0	0	337	0	0	0	0
m3/Mon	6,152	6,169	7,211	8,003	6,791	3,709	3,013	10,621	9,833	4,073	0	0
m3/d	198.5	220.3	232.6	266.8	219.1	123.6	97.2	342.6	327.8	131.4	0.0	0.0

Table A - 6.1(3) Record of Groundwater Consumption (from NJD2 - 1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	272	0	184	0	0	0	197
2	0	0	0	0	0	0	160	0	0	362	249	0
3	0	0	0	0	0	234	0	205	0	0	0	253
4	0	0	0	0	0	0	0	0	310	415	155	0
5	0	0	0	0	0	190	206	271	0	0	0	223
6	0	0	0	0	0	0	0	0	0	329	160	0
7	0	0	0	0	0	0	205	152	431	0	0	279
8	0	0	0	0	0	0	0	0	0	0	320	0
9	0	0	0	0	0	260	163	199	599	362	0	248
10	0	0	0	0	0	349	0	0	0	0	89	0
11	0	0	0	0	0	246	0	199	243	219	0	180
12	0	0	0	0	0	477	203	0	0	0	247	0
13	0	0	0	0	0	0	0	0	234	365	0	200
14	0	0	0	0	0	225	200	204	0	0	218	0
15	0	0	0	0	0	0	0	0	309	370	0	192
16	0	0	0	0	248	222	111	144	0	0	266	0
17	0	0	0	0	0	0	0	0	238	279	0	319
18	0	0	0	0	370	269	19	389	0	0	0	0
19	0	0	0	0	0	0	0	0	333	328	0	189
20	0	0	0	0	370	197	249	0	0	0	0	283
21	0	0	0	0	0	200	0	0	284	319	0	0
22	0	0	0	0	434	192	230	512	0	0	0	197
23	0	0	0	0	0	0	0	0	366	272	0	0
24	0	0	0	0	375	199	246	417	0	0	0	265
25	0	0	0	0	489	0	0	0	282	391	268	0
26	0	0	0	0	490	198	246	462	288	0	0	212
27	0	0	0	0	0	0	0	0	0	295	251	0
28	0	0	0	0	326	167	0	307	310	0	0	205
29	0	0	0	0	0	0	0	0	0	311	312	0
30	0	0	0	0	333	166	0	144	359	0	0	252
31	0	0	0	0	0	0	0	0	0	288	0	0
m3/Mon	0	0	0	0	3,435	4,061	2,238	3,789	4,586	4,905	2,535	3,674
m3/d	0.0	0.0	0.0	0.0	110.8	135.4	72.2	122.2	152.9	158.2	84.5	118.5

Table A - 6.1(4) Record of Groundwater Consumption (from NJD2 - 1996)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	230	0	268	252	0	0	0	0	0	0	0
2	0	0	151	0	0	0	0	351	374	238	0	0
3	0	237	54	220	241	291	0	0	35	272	0	0
4	0	0	0	0	0	0	0	0	366	136	0	0
5	0	401	19	245	227	270	0	345	114	305	0	0
6	88	0	183	0	0	0	0	0	328	172	0	0
7	302	221	0	254	287	404	0	367	45	135	0	0
8	225	0	215	0	0	0	0	0	341	204	0	0
9	0	0	0	251	150	0	401	368	104	216	0	0
10	0	0	176	0	0	0	0	0	333	38	0	0
11	0	205	0	251	218	0	0	272	117	275	0	0
12	271	0	293	0	0	0	0	0	318	272	0	0
13	0	201	0	253	220	0	0	329	28	0	0	0
14	254	0	197	0	0	0	0	0	276	230	0	0
15	0	235	0	260	256	0	0	327	153	273	0	0
16	235	0	304	0	0	361	0	0	286	0	0	0
17	0	251	0	251	284	0	0	366	384	0	0	0
18	212	0	250	0	0	0	0	0	13	0	0	0
19	0	196	0	249	279	0	0	297	343	0	0	0
20	216	0	212	0	0	0	0	0	294	0	0	0
21	0	232	0	283	228	0	0	369	159	0	0	0
22	205	0	222	0	0	51	0	0	0	0	0	0
23	0	194	0	242	282	0	0	68	233	0	0	0
24	202	0	243	0	0	345	0	0	199	0	0	0
25	0	196	0	288	211	0	0	665	0	0	0	0
26	197	0	235	0	0	0	0	0	282	0	0	0
27	0	121	0	279	288	0	0	323	284	0	0	0
28	210	0	252	0	0	172	0	23	0	0	0	0
29	0	89	0	264	0	0	0	366	234	0	0	0
30	207	0	231	0	0	0	0	2	280	0	0	0
31	0	0	0	0	61	0	0	337	0	0	0	0
m3/Mon	2,824	3,009	3,217	3,840	3,484	1,897	401	5,225	5,923	2,766	0	0
m3/d	91.1	107.5	103.8	128.0	112.4	63.2	12.9	168.5	197.4	89.2	0.0	0.0

Table A - 6.1(5) Record of Groundwater Consumption (from NJD4 - 1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	221	0	0	365	389	0
2	0	0	0	0	0	262	0	196	0	0	0	212
3	0	0	0	0	0	0	0	0	0	350	280	0
4	0	0	0	0	0	337	212	260	0	0	0	256
5	0	0	0	0	0	0	0	0	674	372	84	0
6	0	0	0	0	0	0	220	214	254	0	0	285
7	0	0	0	0	0	0	0	0	0	0	215	0
8	0	0	0	0	0	0	223	180	242	0	0	349
9	0	0	0	0	0	0	0	0	0	0	101	0
10	0	0	0	0	0	0	189	151	230	707	0	203
11	0	0	0	0	0	213	191	0	0	0	76	0
12	0	0	0	0	0	0	170	152	222	192	0	237
13	0	0	0	0	0	320	0	160	0	0	228	0
14	0	0	0	0	0	0	0	0	272	355	0	298
15	0	0	0	0	0	359	218	216	0	0	194	0
16	0	0	0	0	0	224	0	0	0	432	0	239
17	0	0	0	0	264	0	65	213	0	0	314	0
18	0	0	0	0	0	0	0	0	676	333	336	266
19	0	0	0	0	314	0	305	402	0	0	383	0
20	0	0	0	0	0	0	0	323	336	331	338	0
21	0	0	0	0	267	0	264	323	0	0	382	260
22	0	0	0	0	0	0	0	0	358	372	358	0
23	0	0	0	0	417	217	109	503	0	0	337	256
24	0	0	0	0	0	0	0	0	366	323	325	0
25	0	0	0	0	0	210	196	350	0	0	0	191
26	0	0	0	0	0	0	0	0	0	337	301	0
27	0	0	0	0	265	180	260	482	0	0	0	380
28	0	0	0	0	0	0	0	0	0	357	238	0
29	0	0	0	0	354	219	0	382	531	0	0	235
30	0	0	0	0	0	0	0	0	0	232	257	0
31	0	0	0	0	316	0	0	0	0	0	0	202
m3/Mon	0	0	0	0	2,197	2,541	2,843	4,509	4,161	5,058	5,139	3,889
m3/d	0.0	0.0	0.0	0.0	70.9	84.7	91.7	145.5	138.7	163.2	171.3	125.5

Table A - 6.1(6) Record of Groundwater Consumption (from NJD4 - 1996)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	122	0	0	0	0	0	377	153	0	0
2	0	220	58	270	289	0	0	0	9	0	0	0
3	0	0	63	0	0	11	336	0	328	21	0	0
4	0	158	143	306	193	263	0	0	0	298	0	0
5	0	0	0	0	0	0	0	0	258	0	0	0
6	0	349	43	272	159	0	324	411	6	0	0	0
7	0	0	244	0	0	22	111	0	377	280	0	0
8	0	248	0	274	294	0	0	415	0	0	0	0
9	322	0	310	0	0	23	0	0	240	0	0	0
10	267	254	0	303	214	0	0	395	32	248	0	0
11	184	0	411	0	0	0	0	89	339	0	0	0
12	0	268	0	267	163	0	327	423	16	62	0	0
13	262	0	248	0	0	0	112	0	353	245	0	0
14	0	266	0	295	234	0	0	409	41	0	0	0
15	262	0	0	0	0	378	229	7	229	0	0	0
16	0	248	0	258	285	0	0	415	111	0	0	0
17	237	0	303	0	0	0	0	0	0	0	0	0
18	0	274	0	299	279	0	380	389	280	0	0	0
19	262	0	308	0	0	0	0	104	156	0	0	0
20	0	240	0	279	282	0	0	357	0	0	0	0
21	231	0	281	0	0	364	223	0	0	0	0	0
22	0	244	0	281	280	0	79	402	211	0	0	0
23	274	0	310	0	0	0	0	0	27	0	0	0
24	0	250	0	297	276	0	188	410	0	0	0	0
25	251	0	307	0	0	0	0	0	243	0	0	0
26	0	0	0	242	280	93	0	417	46	0	0	0
27	255	0	275	0	0	320	0	52	0	0	0	0
28	0	141	0	265	47	336	0	370	231	0	0	0
29	257	0	307	0	0	0	0	0	0	0	0	0
30	0	0	0	255	32	0	303	331	0	0	0	0
31	264	0	281	0	0	0	0	0	0	0	0	0
m3/Mon	3,328	3,160	3,994	4,163	3,307	1,812	2,612	5,395	3,910	1,307	0	0
m3/d	107.4	112.9	128.8	138.8	106.7	60.4	84.3	174.1	130.3	42.2	0.0	0.0

Appendix A - 6.2 Water Use for Center Pivot

Table A - 6.2(1) Record of Water Application at Center Pivot (1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	221	210	226	216	206	257	358	203	0	301	283	207
2	231	190	237	221	280	270	82	365	0	303	297	222
3	36	150	0	263	278	156	0	362	192	308	236	235
4	0	220	0	271	278	168	237	355	362	351	122	241
5	0	212	0	226	280	190	333	363	307	284	122	233
6	0	220	236	236	275	0	358	358	207	295	125	238
7	0	212	239	0	280	0	352	374	207	0	123	238
8	0	214	239	229	278	0	351	359	192	282	284	235
9	0	224	229	237	336	118	356	357	331	292	82	242
10	0	223	159	228	330	230	350	331	185	278	71	242
11	0	151	237	221	335	157	369	357	293	415	69	241
12	214	202	238	226	336	370	352	306	182	0	155	243
13	220	221	239	237	336	404	362	62	170	299	158	239
14	222	223	235	0	280	335	351	356	224	297	156	238
15	229	229	237	237	261	295	359	358	220	293	162	243
16	0	226	218	216	372	224	279	353	250	295	274	227
17	0	167	0	0	381	360	249	356	364	292	277	231
18	0	213	162	162	384	236	252	339	361	295	282	232
19	0	224	221	221	381	0	229	347	355	292	281	237
20	0	220	197	197	384	411	199	359	298	292	273	228
21	0	222	207	207	281	368	193	360	297	297	272	237
22	0	226	210	210	384	364	185	364	292	336	268	238
23	0	230	206	206	482	365	95	353	312	299	277	228
24	0	159	0	0	383	361	236	383	307	309	277	238
25	0	231	231	231	293	355	238	322	103	293	272	229
26	0	227	227	227	262	360	239	398	235	295	208	221
27	0	225	220	220	282	355	216	398	0	294	210	250
28	0	230	221	0	212	364	0	133	304	294	206	232
29	0		216	216	273	360	0	337	301	278	208	221
30	0		197	197	262	354	0	165	301	249	206	216
31	0		0		266		0	0		213		228
x 10m3/Mon	1373	5901	5482	5536	9651	7787	7180	9833	7152	8621	6236	7224
m3/day	442.9	2107.5	1768.4	1852	3113.226	2595.7	2316.1	3171.9	2384	2781	2078.7	2330.32
mm/day	1.5	7.0	5.9	6.2	10.4	8.7	7.7	10.6	7.9	9.3	6.9	7.8

Table A - 6.2(2) Record of Water Application at Center Pivot (1996)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8	226	66	261	265	0	0	0	366	223	0	0
2	0	238	103	264	263	0	0	372	368	233	0	0
3	0	229	107	254	266	262	373	0	364	292	0	0
4	41	219	50	259	204	271	0	0	364	258	0	0
5	93	219	300	257	211	271	0	366	365	269	0	0
6	73	220	208	265	181	0	368	377	361	277	0	0
7	233	219	206	257	269	0	0	382	366	264	0	0
8	224	218	226	260	270	267	0	372	368	278	0	0
9	272	227	297	263	184	24	369	380	364	275	0	0
10	231	242	195	257	199	0	0	374	363	261	0	0
11	127	228	431	258	229	0	0	364	370	268	0	0
12	340	227	253	265	151	0	368	367	365	270	0	0
13	219	228	216	258	205	0	0	370	364	261	0	0
14	223	229	211	264	214	0	0	369	358	267	0	0
15	330	265	0	264	212	364	367	374	354	272	0	0
16	243	225	304	261	265	0	0	374	351	0	0	0
17	219	229	262	265	265	0	0	366	364	0	0	0
18	80	218	263	267	266	375	365	371	360	0	0	0
19	223	217	267	260	262	0	0	368	351	0	0	0
20	220	217	257	268	265	0	0	369	240	0	0	0
21	220	218	264	265	263	374	224	377	224	0	0	0
22	224	218	265	263	263	0	0	374	228	0	0	0
23	219	218	263	265	263	0	0	373	221	0	0	0
24	221	215	263	268	265	376	290	374	279	0	0	0
25	221	218	266	267	263	0	0	322	252	0	0	0
26	220	58	256	263	265	0	0	354	275	0	0	0
27	221	145	263	267	281	386	289	401	279	0	0	0
28	218	105	265	267	58	0	0	367	277	0	0	0
29	230		261	264	0	0	0	364	252	0	0	0
30	231		265	267	0	364	375	356	218	0	0	0
31	231		276		0		0	376		0		0
x 10m3/Mon	5856	5935	7129	7883	6547	3331	3388	10353	9631	3968	0	0
m3/day	1889	2120	2300	2628	2112	1111	1093	3340	3210	1280	0	0
mm/day	6.3	7.1	7.7	8.8	7.0	3.7	3.6	11.1	10.7	4.3	0.0	0.0

Appendix A - 6.3 Water Use for Linear Movement

Table A - 6.3 Record of Water Application at Linear Move (1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	122	117	107	110	0	0	0	0	0	0	0	0
2	123	119	121	107	0	0	0	0	0	0	0	0
3	0	80	0	147	0	0	0	0	0	0	0	0
4	0	128	0	139	0	0	0	0	0	0	0	0
5	0	113	0	107	0	0	0	0	0	0	0	0
6	0	121	125	125	0	0	0	0	0	0	0	0
7	0	113	123	0	0	0	0	0	0	0	0	0
8	0	111	123	125	0	0	0	0	0	0	0	0
9	0	127	112	123	0	0	0	0	0	0	0	0
10	0	126	87	112	0	0	0	0	0	0	0	0
11	0	88	121	117	0	0	0	0	0	0	0	0
12	0	127	120	124	0	0	0	0	0	0	0	0
13	0	125	120	125	0	0	0	0	0	0	0	0
14	0	127	119	0	0	0	0	0	0	0	0	0
15	0	125	121	120	0	0	0	0	0	0	0	0
16	0	117	102	102	0	0	0	0	0	0	0	0
17	0	801	0	0	0	0	0	0	0	0	0	0
18	0	109	100	100	0	0	0	0	0	0	0	0
19	0	116	110	110	0	0	0	0	0	0	0	0
20	0	107	100	100	0	0	0	0	0	0	0	0
21	0	112	85	85	0	0	0	0	0	0	0	0
22	0	109	85	85	0	0	0	0	0	0	0	0
23	0	109	90	90	0	0	0	0	0	0	0	0
24	0	85	0	0	0	0	0	0	0	0	0	0
25	0	119	119	119	0	0	0	0	0	0	0	0
26	0	108	101	101	0	0	0	0	0	0	0	0
27	0	107	110	110	0	0	0	0	0	0	0	0
28	0	118	117	117	0	0	0	0	0	0	0	0
29	0		104	0	0	0	0	0	0	0	0	0
30	0		100	0	0	0	0	0	0	0	0	0
31	0		0		0		0	0		0		0
x 10m3 / Mon	245	3864	2722	2700	0	0	0	0	0	0	0	0
m3/day	79	1380	878	900	0	0	0	0	0	0	0	0
mm/day	0.4	7.7	4.9	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix A - 6.4 Water Use for Tree

Table A - 6.4(1) Record of Water Application for Trees (1995)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	92	60	60	65	68	60	30
2	0	0	0	0	0	82	61	57	31	57	68	36
3	0	0	0	0	0	86	101	57	33	65	71	71
4	0	0	0	0	0	78	59	57	59	65	65	28
5	0	0	0	0	0	50	57	56	55	64	67	38
6	0	0	0	0	0	90	63	75	62	65	67	30
7	0	0	0	0	0	81	61	57	25	64	65	30
8	0	0	0	0	0	78	61	47	57	62	63	30
9	0	0	0	0	0	55	61	57	58	65	54	31
10	0	0	0	0	0	88	61	64	65	67	64	31
11	0	0	0	0	0	275	61	57	68	64	62	30
12	0	0	0	0	0	81	61	58	64	54	61	30
13	0	0	0	0	0	94	53	51	57	59	62	40
14	0	0	0	0	0	75	62	62	67	68	63	27
15	0	0	0	0	0	132	62	76	62	76	62	30
16	0	0	0	0	100	42	64	65	65	73	74	31
17	0	0	0	0	201	60	64	68	67	72	59	34
18	0	0	0	0	154	67	64	0	68	62	30	30
19	0	0	0	0	82	10	24	56	61	71	58	32
20	0	0	0	0	25	62	72	66	63	64	14	36
21	0	0	0	0	136	68	68	67	63	64	4	37
22	0	0	0	0	62	63	58	66	65	63	0	45
23	0	0	0	0	75	63	0	66	64	64	0	11
24	0	0	0	0	101	62	60	66	63	63	0	32
25	0	0	0	0	100	62	62	68	63	64	38	31
26	0	0	0	0	49	59	61	65	62	63	32	25
27	0	0	0	0	99	60	66	62	62	64	69	21
28	0	0	0	0	99	60	58	41	62	66	30	25
29	0		0	0	97	61	29	64	65	60	61	23
30	0		0	0	101	59	0	46	64	60	29	24
31	0		0		87		32	55		60		25
x 10m3 / Mon	0	0	0	0	1587.5	2293.3	1774.6	1786.8	1782.5	1993.3	1450.5	991.6
m3/day	0	0	0	0	512.1	764.4	572.5	576.4	594.2	643.0	483.4	319.9
lit./No./day	0.0	0.0	0.0	0.0	141.5	211.3	158.2	159.3	164.2	177.7	133.6	88.4

No. of Trees 3618 Nos

Table A - 6.4(2) Record of Water Application for Trees (1996)

unit: x 10 m3

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	25	28	24	25	24	14	0	6	22	49	0	0
2	25	25	17	15	14	22	0	23	22	42	0	0
3	24	25	20	16	14	0	23	6	21	40	0	0
4	25	27	19	25	15	14	0	5	21	40	0	0
5	25	21	25	16	25	15	0	24	21	39	0	0
6	25	22	20	16	14	23	23	23	22	43	0	0
7	25	21	16	25	14	15	0	23	21	39	0	0
8	25	21	21	16	15	15	0	22	21	39	0	0
9	27	23	21	21	24	11	23	23	21	40	0	0
10	26	23	21	21	14	0	0	23	21	38	0	0
11	26	26	15	27	14	0	0	23	29	38	0	0
12	26	23	15	16	14	0	23	23	30	35	0	0
13	26	24	15	16	27	0	5	23	33	41	0	0
14	29	24	16	18	14	0	6	23	38	38	0	0
15	29	22	0	18	14	27	18	23	29	38	0	0
16	22	21	0	25	14	17	0	23	35	0	0	0
17	24	28	16	8	24	0	5	19	32	0	0	0
18	19	22	23	24	14	0	23	22	45	0	0	0
19	23	23	18	16	29	29	6	24	32	0	0	0
20	23	27	15	26	14	0	5	23	32	0	0	0
21	23	24	16	16	17	17	21	23	33	0	0	0
22	22	0	16	16	15	11	11	22	33	0	0	0
23	23	23	20	27	15	0	7	22	32	0	0	0
24	23	23	16	15	15	18	23	22	32	0	0	0
25	23	24	16	15	24	0	4	22	32	0	0	0
26	20	30	16	14	15	11	6	22	28	0	0	0
27	22	24	26	26	14	23	23	24	35	0	0	0
28	21	23	11	15	15	0	6	15	32	0	0	0
29	22	23	12	14	24	0	6	20	42	0	0	0
30	22		11	15	15	23	23	23	32	0	0	0
31	22		15		14		6	23		0		0
x 10m3/Mon	740.1	671.3	506.6	563.1	533.4	306.8	293.6	638.7	880.2	599.6	0	0
m3/day	238.7	231.5	163.4	187.7	172.1	102.3	94.7	206.0	293.4	193.4	0.0	0.0
lit./No./day	66.0	64.0	45.2	51.9	47.6	28.3	26.2	56.9	81.1	53.5	0.0	0.0

No. of Trees 3618 Nos

Fig. A-6.5 Location Map of Wells in NARS

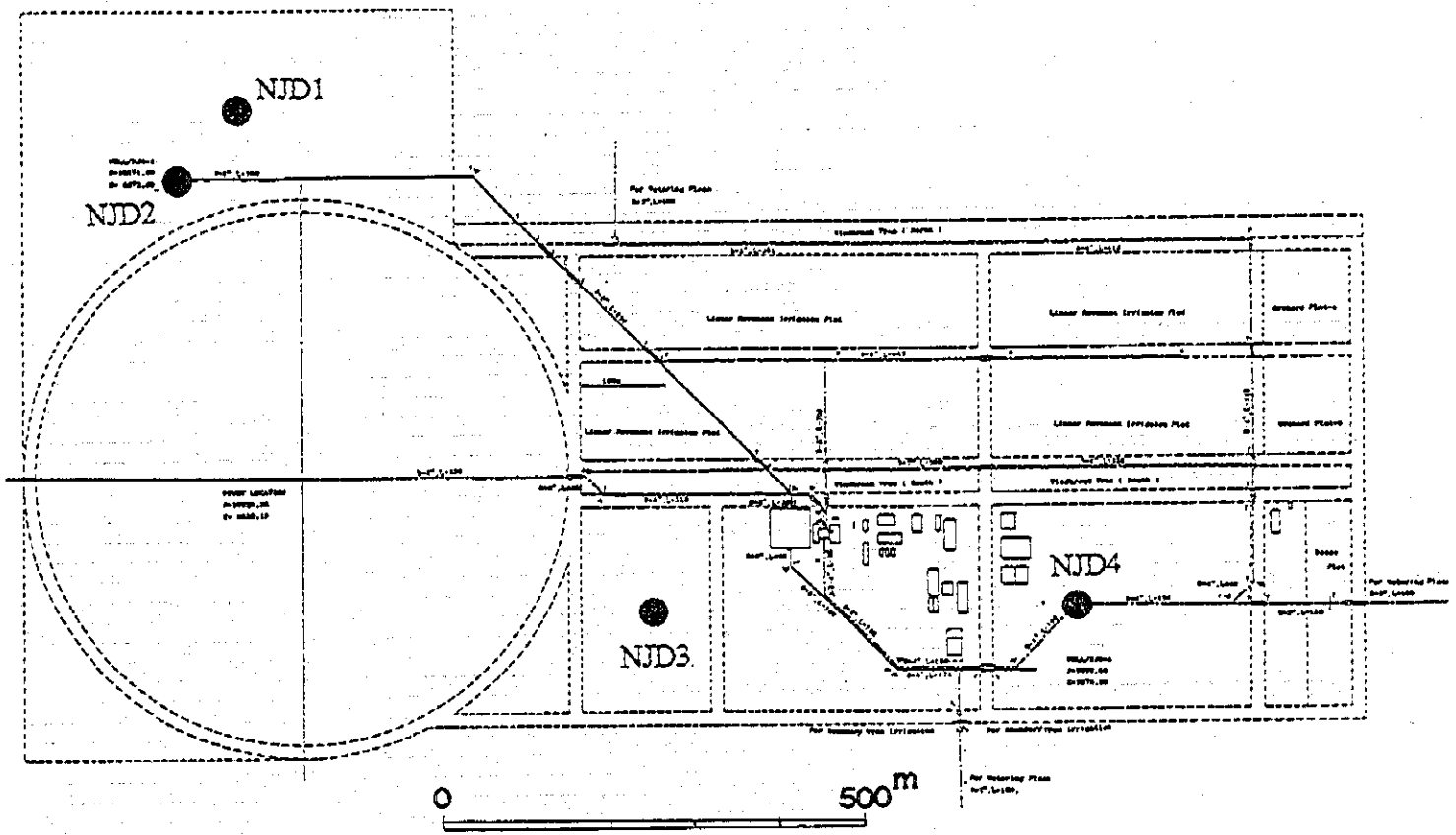
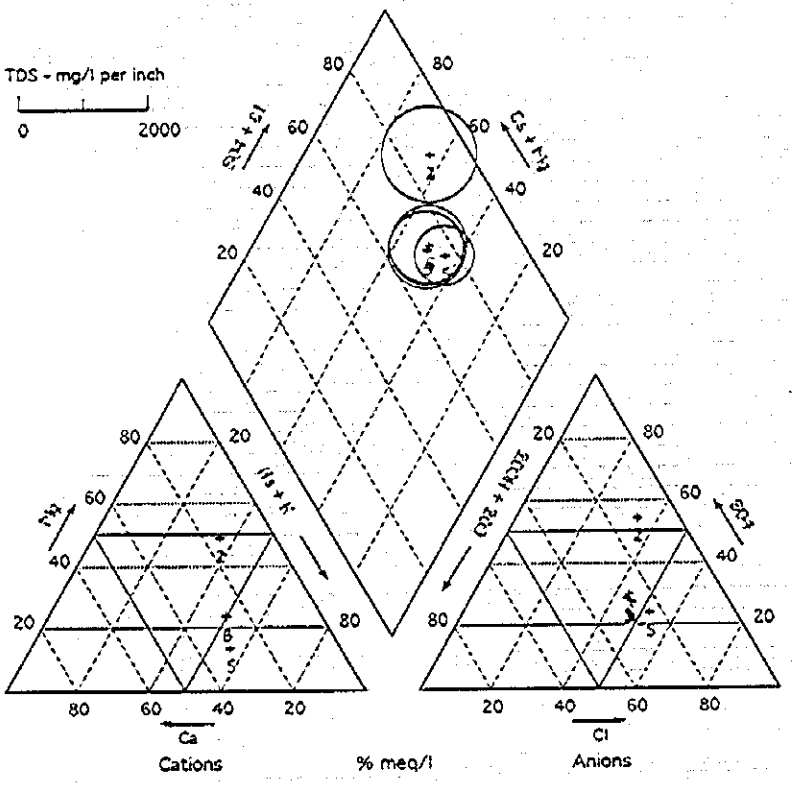


Fig. A-6.6 The Result of Water Quality Analysis



The Result of Water Quality Analysis (1/2)

No.	TDS	Sample	No.	TDS	Sample
1	1473	NJD-2/17/7/95			
2	1482	NJD-4/17/7/95			
3	1195	NJD-2/19/6/96			
4	1176	NJD-4/19/6/96			
5	937	NJD-2/25/9/96			
6	1200	NJD-4/25/9/96			

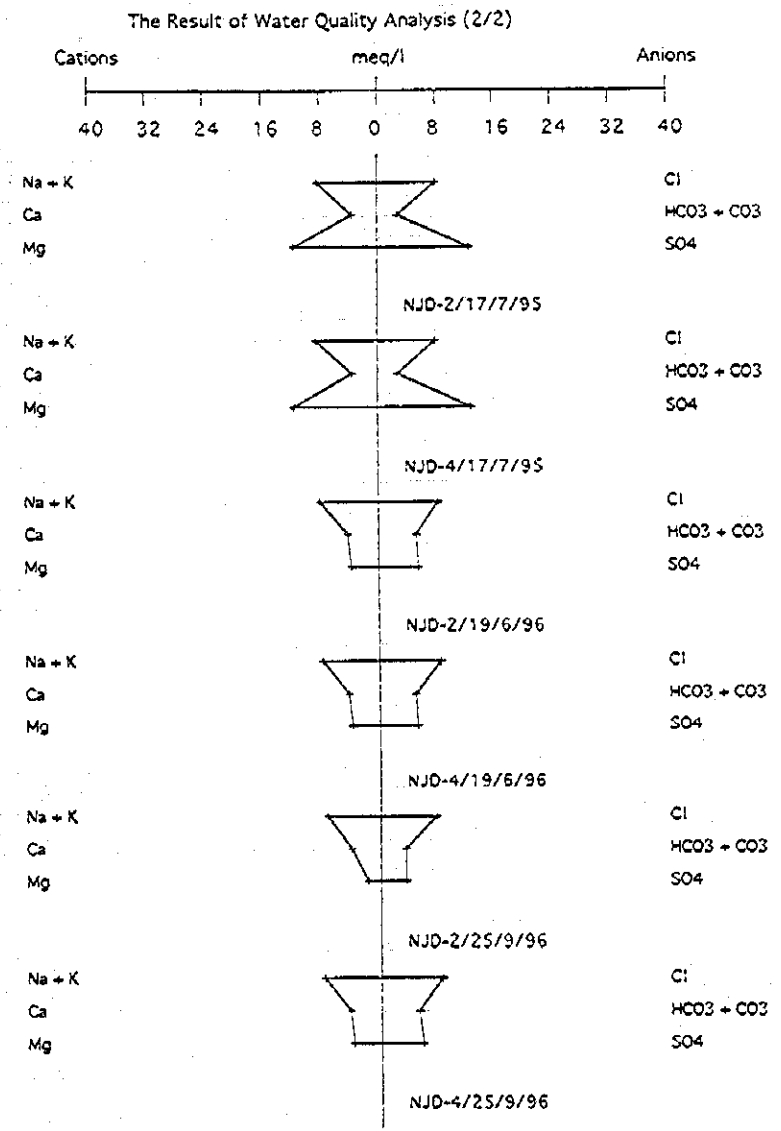
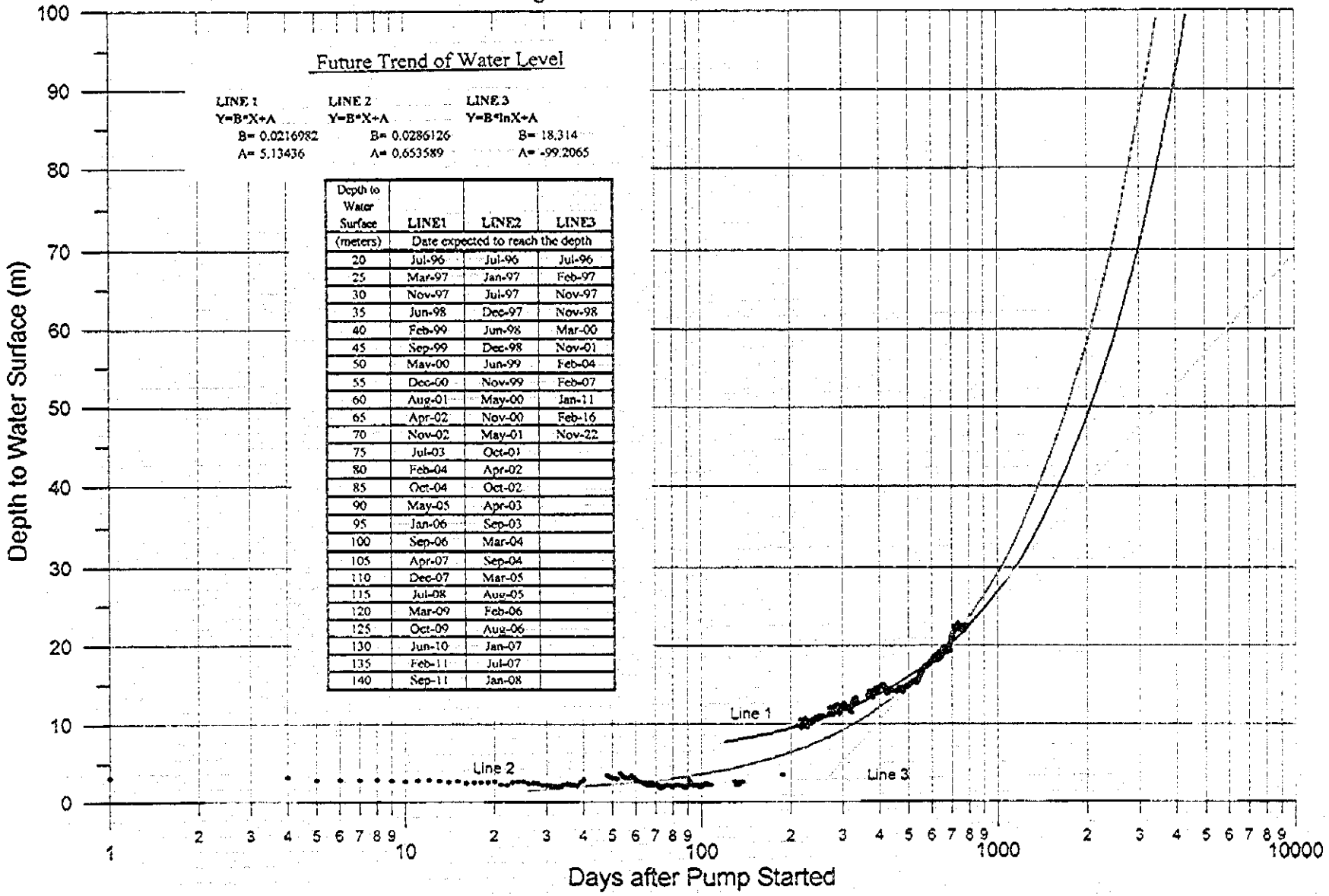


Fig. A-6.7 Future Trend of Water Level



Depth to Water Surface	LINE1	LINE2	LINE3
(meters)	Date expected to reach the depth		
20	Jul-96	Jul-96	Jul-96
25	Mar-97	Jan-97	Feb-97
30	Nov-97	Jul-97	Nov-97
35	Jun-98	Dec-97	Nov-98
40	Feb-99	Jun-98	Mar-00
45	Sep-99	Dec-98	Nov-01
50	May-00	Jun-99	Feb-04
55	Dec-00	Nov-99	Feb-07
60	Aug-01	May-00	Jan-11
65	Apr-02	Nov-00	Feb-16
70	Nov-02	May-01	Nov-22
75	Jul-03	Oct-01	
80	Feb-04	Apr-02	
85	Oct-04	Oct-02	
90	May-05	Apr-03	
95	Jan-06	Sep-03	
100	Sep-06	Mar-04	
105	Apr-07	Sep-04	
110	Dec-07	Mar-05	
115	Jul-08	Aug-05	
120	Mar-09	Feb-06	
125	Oct-09	Aug-06	
130	Jun-10	Jan-07	
135	Feb-11	Jul-07	
140	Sep-11	Jan-08	

APPENDIX - 7
EXPERIMENTAL TRIALS

Appendix 7

A-7.1 Main proceedings of Rhodes grass cultivation in 1996

Month	Trials			Change of amount of irrigation water	Harvesting of Rhodes grass	Interrupted irrigation
	Trial 1	Trial 2	Trial 3			
February					27-Feb.~	Daily irrigation
March	Started the Trial 1 on irrigation and fertilization on 13-Mar.			Changed on 13-Mar.	12-mar. (8th)	
April						
May					4-May~ 14-May (9th)	Once in every 3 days from late May
June	Changed level on 10-Jun.			Changed on 10-Jun.		
July			Applied manure on		20-Jul.~ 28-Jul. (10th)	
August		Applied K2SO4 on 13/19-Aug.	30-Jul./13-Aug.			Restarting daily irrigation on 6-Aug.
September					20-Sep~	
October	Changed level on 2-Oct.			Changed on 2-Oct.	1-Oct. (11th)	

A-7.2 Results of trials

Table A-7.2.1 Effect of manure application on yield of Rhodes grass (1996)

Treatment	Location	Dry matter yield (ton/ha)
Manure		September
Applied	B-2	2.77
	C-2	1.79
	A-2	1.38
	D-2	0.52
Average		**1.62**
Not applied	B-1	3.69
	C-1	2.60
	A-1	1.95
	D-1	1.59
Average		**2.46**

Table A-7.2.2 Effect of potassium application on yield of Rhodes grass (1996)

Treatment	Location	Dry matter yield (ton/ha)
Potassium		September
Applied	B-1	3.69
	B-2	2.77
	A-1	1.95
	A-2	1.38
Average		**2.45**
Not applied	C-1	2.60
	C-2	1.79
	D-1	1.59
	D-2	0.52
Average		**1.63**

A-7.3 Farm Works Observation on Harvesting of Rhodes Grass

1. Observation of farm works during the harvesting of Rhodes grass in September, 1995

1) Work Condition

(1) Farm Machinery

Tractors :	3	(MF 390, MF 390 and MF 290)
Mower :	1	(John Deer 135, width of cutting ; 1.7 m)
Rake :	1	(4 wheels with fingers, 1 pass after drying one day, collecting 2 rows for baler. Since 12 September, one wheel is removed, and raking is done with 3 wheels, because of reducing quantity of grass of a windrow to avoid the baler's trouble.)
Tight baler :	1 (+1)	(Vicon SP 451, one baler is spare for mechanical trouble.)
Trailer	2	(9 x 2.5 m, being capable of loading 220 bales [11 x 5 x 4 layers = 220 bales]. When one baler is transporting in field, another stays at the keeping place for heating up bales.)
(Buyer's truck		Loading capacity : 2 tones, number of loading hay bales : 240 bales [5 x 6 x 8 layers = 240 bales])

(2) Operators and labors

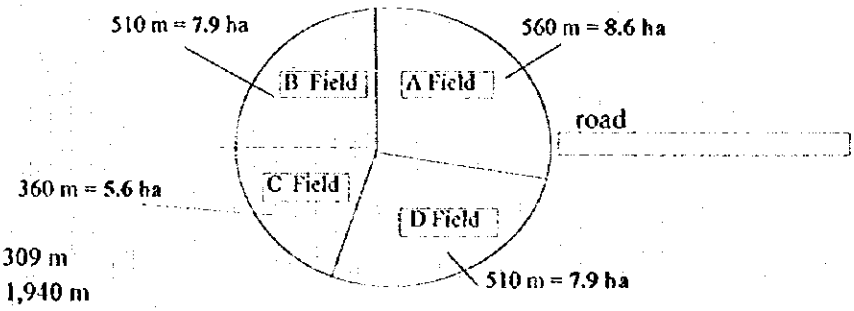
Operators :	3	(Operators for tractors)
Labors :	6	3 labors for picking up and loading the bales on the trailer, and 3 labors for heating up the bales at the keeping place where is at 100 meter's distance from the field and for loading bales to buyer's trucks.

(3) Workday

In the morning :	9:00 a.m. ~ 12:30 a.m. (3.5 hours)
In the afternoon :	3:00 p.m. ~ 6:00 p.m. (3 hours)

(4) Division of the Center Pivot Field of 30 ha

To reduce of interrupting period of irrigation, the Center Pivot Field of 30 ha was divided into four parts. After the whole hay making works of each part, the works of the next part of field was started.



Radius of field = 309 m
Circumference = 1,940 m

(5) Irrigation

Irrigated except the working parts of field.
Interrupted period of irrigation was four days in each divided part of field.
Irrigator's speed : 45%.

(6) Weather

Fine
Max. temperature : 35 ~ 40 C
Min. temperature : 20 ~ 23 C
Humidity % : 12 ~ 20% in the daytime(min.) and 70 ~ 80% in night(max)
Wind velocity : 1 ~ 6 m / sec. all day

2) Work schedule

Date		Tractor A		Tractor B	Tractor C	Remarks
		Cutting	Raking	Baling	Transporting	
Sept. 4	a.m.	D Field				
	p.m.	D Field				
5	a.m.	D Field				
	p.m.		D Field			
6	a.m.		D Field	D Field	D Field	
	p.m.	A Field		D Field	D Field	
7	a.m.	A Field		D Field	D Field	
	p.m.	A Field		D Field	D Field	
8	a.m.		A Field			
	p.m.		A Field			
9	a.m.	B Field		A Field	A Field	
	p.m.	B Field		A Field	A Field	
10	a.m.	B Field		A Field	A Field	
	p.m.		B Field	A Field	A Field	
11	a.m.		B Field	B Field	B Field	Baler's troubles, and
	p.m.		B Field	B Field	B Field	doing raking over again.
12	a.m.		B Field	B Field	B Field	Baler's troubles, and
	p.m.	C Field		B Field	B Field	doing raking over again.
13	a.m.	C Field		B Field	B Field	
	p.m.		C Field	B Field	B Field	
14	a.m.		C Field	C Field	C Field	Baler's troubles
	p.m.			C Field	C Field	
15	a.m.			C Field	C Field	Baler's troubles
	p.m.			C Field	C Field	
16	a.m.			C Field	C Field	Baler's troubles
	p.m.			C Field	C Field	
17	a.m.			C Field	C Field	Baler's troubles

2. Observation in November, 1995

1) Work schedule

Date		Tractor A		Tractor B	Tractor C
		Cutting	Raking	Baling	Transporting
Nov. 3	a.m.	D field			
	p.m.	D field			
4	a.m.	D field			
	p.m.				
5	a.m.		D field		
	p.m.				
6	a.m.		D field	D field	D field
	p.m.			D field	D field
7	a.m.	C field			D field
	p.m.	C field		D field	D field
8	a.m.	C field		D field	D field
	p.m.				
9	a.m.				
	p.m.				
10	a.m.		C field		
	p.m.		C field	C field	
11	a.m.	A field		C field	C field
	p.m.	A field			C field
12	a.m.	A field	A field		C field
	p.m.	B field		A field	C field
13	a.m.	B field		A field	A field
	p.m.		B field	A field	A field
14	a.m.		B field		A field
	p.m.				
15	a.m.		B field	B field	B field
	p.m.			B field	B field
16	a.m.			B field	B field
	p.m.				B field

A-7.4 Results of Lysimeter Trials

Table A-7.4.1 Soil moisture content in lysimeter

Treatment		Items		Moisture (%)					
Irrigation	Manure	Plot NO.	Depth	16-Jul.	22-Jul.	30-Jul.	5-Aug.	13-Aug.	20-Aug.
Control	Applied	1, 5	0 ~ 20 cm	14.0	6.2	6.5	9.0	14.0	9.4
			20 ~ 50	13.7	8.3	6.1	9.5	13.0	7.7
			50 ~ 80	15.9	12.7	11.6	14.1	14.6	12.5
	None	3, 7	0 ~ 20 cm	13.1	7.9	8.4	10.0	13.0	10.1
			20 ~ 50	14.8	9.5	8.6	11.7	12.2	11.5
			50 ~ 80	16.1	12.5	12.6	13.6	15.9	13.4
		Average	0 ~ 20 cm	13.6	7.0	7.4	9.5	13.5	9.7
			20 ~ 50	14.3	8.9	7.4	10.6	12.6	9.6
			50 ~ 80	16.0	12.6	12.1	13.8	15.2	12.9
Low	Applied	2, 6	0 ~ 20 cm	10.7	5.3	3.7	6.4	12.9	8.2
			20 ~ 50	12.3	8.8	7.6	8.4	12.9	9.2
			50 ~ 80	14.0	10.3	9.3	11.8	14.2	9.3
	None	4, 8	0 ~ 20 cm	10.6	5.3	7.8	5.5	9.4	6.6
			20 ~ 50	11.5	7.5	8.0	6.2	9.0	6.8
			50 ~ 80	14.7	12.9	12.4	11.3	12.3	11.0
		Average	0 ~ 20 cm	10.6	5.3	5.8	5.9	11.1	7.4
			20 ~ 50	11.9	8.1	7.8	7.3	10.9	8.0
			50 ~ 80	14.4	11.6	10.9	11.6	13.3	10.2

Table A-7.4.2 pH and EC of drainage water in lysimeter

(1) pH

Treatment		Date	18-Jun.	1-Jul.	7-Jul.	14-Jul.	21-Jul.	6-Aug.
Irrigation	Manure							
Control	Applied	Plot-1	7.8	7.6	7.6	7.7	8.2	7.7
		5	7.5	7.0	7.0	7.8	8.0	8.0
		Average	7.7	7.3	7.3	7.8	8.1	7.9
	None	3	7.6	7.3	7.3	7.8	8.1	8.2
		7	7.6	7.1	7.1	7.5	8.2	8.5
		Average	7.6	7.2	7.2	7.7	8.2	8.4
	Average		7.6	7.3	7.3	7.7	8.1	8.1
Low	Applied	2	7.6	7.5	7.5	7.9	8.3	8.4
		6	7.9	7.3	7.3	7.7	8.1	8.2
		Average	7.8	7.4	7.4	7.8	8.2	8.3
	None	4	7.7	8.2	8.2	7.8	8.2	8.4
		8	7.8	7.2	7.2	7.7	8.2	8.2
		Average	7.8	7.7	7.7	7.8	8.2	8.3
	Average		7.8	7.6	7.6	7.8	8.2	8.3

(2) EC (ms/cm)

Irrigation	Manure	Date	18-Jun.	1-Jul.	7-Jul.	14-Jul.	21-Jul.	6-Aug.
Control	Applied	Plot-1	4.6	5.2	5.2	6.5	6.5	7.5
		5	4.9	5.6	5.6	5.9	6.3	5.9
		Average	4.8	5.4	5.4	6.2	6.4	6.7
	None	3	5.6	7.3	7.3	6.4	6.6	6.2
		7	5.5	5.6	5.6	6.6	8.2	6.7
		Average	5.6	6.5	6.5	6.5	7.4	6.5
	Average		5.2	5.9	5.9	6.4	6.9	6.6
Low	Applied	2	5.5	5.8	5.8	6	6.5	6.8
		6	5.3	5.6	5.6	7.9	8.9	9.3
		Average	5.4	5.7	5.7	7.0	7.7	8.1
	None	4	4.4	4.7	4.7	6.8	6.4	6.6
		8	5.9	7.1	7.1	7.6	7	8.8
		Average	5.2	5.9	5.9	7.2	6.7	7.7
	Average		5.3	5.8	5.8	7.1	7.2	7.9

Table A-7.4.3 Yield of Rhodes grass in lysimeter

Treatment		Date	6-Apr.	25-Jun.	20-Aug.
Irrigation	Manure		kg/9m2	kg/9m2	kg/9m2
Control	Applied	Plot-1	6.48	6.54	4.85
		5	4.64	5.72	7.48
		Average	5.56	6.13	6.16
	None	3	6.17	5.95	8.30
		7	6.59	4.76	9.00
		Average	6.38	5.36	8.65
	Average		5.97	5.75	7.41
Low	Applied	2	9.77	5.53	9.71
		6	6.38	7.69	7.41
		Average	8.08	6.61	8.56
	None	4	4.24	7.40	7.03
		8	5.92	8.45	6.41
		Average	5.08	7.92	6.72
	Average		6.58	7.27	7.64

A-7.5 Experimental Plan of NARS

No.	Expected subjects	Objectives	Trial Field
1	**Irrigation**		
	1) Saving methods of irrigation water in summer in Rhodes grass cultivation	To clarify the methods of saving irrigation water so as to make the effect of interrupted irrigation in summer on growth of Rhodes grass as economically small as possible on the basis of experience in last summer.	Center Pivot field
	2) Comparison of irrigation by Center Pivot system or Linear Movement system with drip irrigation in vegetable cultivation	To clarify the saving amount of water in the drip irrigation method in comparison with Center Pivot or Linear Movement systems in vegetables cultivation.	Center Pivot field, Linear Movement field, vegetable field
	3) Prevention against salt accumulation in surface soils by irrigation and drainage	To clarify the relationship of salt accumulation and drainage and leaching factor, besides monitoring of soil in NARS and the pilot farms in Nejd.	Lysimeter
	4) Appropriate water use in cultivation of various crops	To clarify the effects of amount of irrigation water use on growth and yield of various crops in each season to make the standard for effective irrigation water use.	Center Pivot field, Linear Movement field, vegetables field
2	**Crop cultivation**		
	1) Selection of suitable varieties of vegetables	To select suitable varieties of carrot, onion, squash, green pepper, coosa, potatoes, etc. as winter vegetables and melon as summer vegetable.	Linear Movement field, vegetables field
	2) Selection of suitable fodder crops in winter	To select the suitable winter fodder crops such as Rhodes grass as annual winter crop, Italian ryegrass, alfalfa, barley, sorghum, etc.	Center Pivot field
	3) Suitable cropping season of various crops	To clarify the suitable seeding time for various vegetables in winter, melons in summer and annual fodder crops in winter.	Center Pivot field, Linear Movement field, vegetables field
	4) Reasonable methods of fertilization and irrigation in crop cultivation	To clarify the effect of urea application by injection system and other fertilizer application by machine or hand on growth and yield of various crops and trees under the condition of various irrigation water use.	Center Pivot field, Linear Movement field, vegetables field, fruits trees field, windbreak trees
	5) Pot culture of vegetables	To clarify the effects of sizes and materials of pot, materials of nursery bed such as paste of clayey soil, fermented dung of ruminants, etc. and raising management of seedling on growth and yield of vegetables after transplanting.	vegetables field
	6) Control methods of weed and pests	To observe the seasonal prevalence of diseases, insects including the insects vector of virus and weeds, and to establish forecasting of occurrence of them. Besides, to clarify the effective methods of control for them by use of post-emergence herbicides and pesticides and by controls to prevent from occurrence on the basis of the forecasting of occurrence.	Center Pivot field, Linear Movement field, vegetables field, fruits trees field, windbreak trees

No.	Expected subjects	Objectives	Trial Field
7)	Diagnoses of macro- and micro-elements deficiency and excess and fertilization	To establish the standard application rates of fertilizers of macro- and micro-elements. Trials are planned when the symptoms of deficiency or excess of macroelements, such as N, P and K, and microelements, such as Ca, Mg, B, Mo, Cu and Zn, are observed and the monitoring results of chemical analysis of plant and soil show the apprehension of troubles on the growth of crops.	Center Pivot field, Linear Movement field, vegetables field, fruits trees field, windbreak trees
3	**Mechanization**		
1)	Method of subsoiling to improve the soil compaction induced by mechanization	To clarify the effects of subsoiling on growth of Rhodes grass to improve the soil compaction induced by farm machinery movement in the field	Center Pivot field
2)	Methods of tillage, leveling and sowing in cultivation of crops following Rhodes grass	To clarify the seeding methods to obtain high accuracy of seeding work with machine under condition of much residues of Rhodes grass and minimal tillage to build up organic matter in the top soil.	Center Pivot field
3)	Effective farm work methods in mechanized crop cultivation	To clarify the effective mechanized working system in cultivation of various crops, firstly the working system of Rhodes grass harvesting to shorten the interruption of irrigation as short as possible for regrowth of grass.	Center Pivot field
4	**Crop rotation**		
1)	Cropping patterns suitable to the Nejd area by farming size	To clarify the suitable cropping sequence of fodder crops and various vegetables to prevent from injury by continuous cropping.	Center Pivot field, Linear Movement field
5	**Livestock farming**		
1)	Open yard feeding of goats	To clarify the feeding method of goats by open yard feeding in summer and feeding hay in winter, especially in consideration of deficiency or excess of some microelements, investigating quantity of feed intake, chemical components of feeds, gains in weight, animal hygiene, etc.	Center Pivot field

APPENDIX - 8
QUESTIONNAIRE SURVEYS

Appendix 8-1 Results of questionnaire survey of farmers in Salalah

A. Purpose of the survey

The Salalah Plain is bounded by the Jabal and the coast, extending 8 km from south to north and 300 km from east to west and has been a center of the Dhofar Region. The purpose of this survey is to clarify the socio-economic and farming conditions in this area and to provide reference information to compare with those in Nejd and Jabal.

B. Methods of the survey

1) Time of survey: December, 1995
2) Location: Salalah in Dhofar
   Al-O'kdain, Taqah, Al-Oarqd, Al-Owqdain, Salalah, Al-Shorgen, Al-Wadi, Ad-Dahariz and Al-Haffah in Salala-subregion
3) Sampling size: 20 farmers
4) Survey methods: Interview

C. Results of the survey

The results were mainly analyzed and summarized on the items for which relatively many replies could be received from the surveyed farmers among the items of the questionnaire. The results are as followed, supplementing with the results of FAO report (Soil survey and land classification project, Report on farming systems survey, Salalah Plain by farming system section, MAF and Food and Agriculture Organization of the United Nation, Muscat, April 1992; hereinafter refer to as "FAO report")

C-1. General background information of the Salalah Plain

Summarization of the FAO report on this paragraph is as follows;

(1) Annual average rainfall is 110 mm in the plain.

(2) The current total population in the plain is estimated at about 77,000 people divided in the ratio of 2:1 between nationals and expatriates. At present population grows at an estimated annual rate of 3.7% and local population is expected to triple within 20 years.

(3) In short the development of Salalah is now under way at an increasing speed. Agriculture in this development society is loosing its importance as an income generating activity. Due to the high levels of non-farm income and exclusive use of expatriates labor, as well as the existence of all sorts of subsidy programs in both agriculture and non-agricultural sectors, land owners do not respond to price and non-price incentives as if they were still subsistence farmers.

(4) The land use pattern in Salalah Plain is given in Table A.8.11. It shows that 3,543 ha are put in to agricultural use, out of which around 75% is used for the cultivation of various crops.

Table A-8.1.1 Land use pattern in Salalah plain (1991, FAO's report)

Type of use	Area (ha)	%
Net cultivated area	2,676	76
Fallow (current & permanent)	271	8
Cultivable waste land	357	10
Ornamental plants and park	40	1
Farm building	163	5
Other non-agricultural use	37	1
Total	3,543	100

Table A-8.1.2 Land Distribution Pattern in Salalah Plain

Size of Holding	No. of Farms	% of Total	Total area (Fedan)	%	Average (Fedan)	Average (ha)
< 3	253	31.8%	417.0	5.9%	1.6	0.7
3 - 6	306	38.4%	1,286.0	18.2%	4.2	1.8
6 - 10	160	20.1%	1,182.7	16.7%	7.4	3.1
10 - 20	55	6.9%	628.8	8.9%	11.4	4.8
20 - 50	13	1.6%	341.8	4.8%	26.3	11.0
50 - 100	5	0.6%	306.1	4.3%	61.2	25.7
> 100	4	0.5%	2,906.3	41.1%	726.6	305.2
Total	796	100.0%	7,068.7	100.0%	8.9	3.7

Source : Land use report, FAO, 1991

The above table shows that the 4 large farms, namely the Royal Farm, the Dhofar Cattlefeed Company, the Livestock Research Farm and one private farm, own 41% of total agricultural land, while 90.4% of farms are of less than 4.2 ha in size and own only 40.8% of the total area.

(5) Cropping pattern by size class of farms in Salalah are shown in the table below. As around 60% of operated land is put under perennial fruit trees and grasses, only 40% is available for cultivation during Khareef and Rabi season. Mostly vegetables are grown in these lands. Besides, conclusions by use of the data in this table are as follows;

1) About 13% of the operated land was kept fallow. The extent of fallow land increased with size of land holding.
2) There existed a marked difference in cropping pattern between different size class of farms. The marginal farms of size of holding less than 3 feddans had put more area under fruit trees (36.3%) and grasses (29.8%), while the farms of size group 6 to 7 had more area under vegetables (53.3%).
3) In the category of fruit crops, banana was the major crop followed by coconut. But it was observed that farmers try to grow all kind of fruit trees, the number may be even 3 to 5 plants, basically for self consumption.
4) As livestock is an important component of the farm household system, fodder and grasses got importance in allocation of area on marginal and small farms.
5) Among the vegetables, tomatoes were the most popular, followed by pepper and chilies. Tomatoes can be called the main vegetable crop of the area and is being supplied to other parts of Oman.

supplied to other parts of Oman.

6) A comparison of land uses by salinity classes clearly shows that bananas practically disappear when the salinity is above 5 millimho's per cm, while also grasses are becoming more important. The area has attained a critical limit of salinity because only 30% of the area has safe water quality and 50% is in the critical zone of 3 to 7 mS/cm.

Table A-8.1.3 Cropping pattern by size class of farms in Salalah

Crops	% crop area by size class (feddan)				All farms
	< 3	3-6	6-7	> 7	
A. Fruit crops					
banana	12.8	8.8	8.3	7.9	9.6
banana & papaya	15.0	5.8	1.8	23.2	8.9
coconut	6.1	9.7	4.8	-	6.6
mixed fruit trees	1.9	2.6	2.4	8.6	3.0
other fruit	0.5	-	0.4	-	0.2
Subtotal	36.3	26.9	17.7	39.7	28.3
B. Fodder and grasses					
Alfalfa	3.6	1.4	-	-	1.5
Elephant grass	9.8	6.4	1.2	-	5.3
Rhodes grasses	14.0	15.6	8.1		12.5
Sorghum for fodder	2.4	2.5	-	-	1.6
Subtotal	29.8	25.9	9.3		20.9
C. Vegetables					
Pepper and chilies	4.0	2.1	1.1	-	2.1
Tomatoes	3.0	7.8	9.8	-	6.3
Cucumber	1.3	2.2	2.7	-	1.9
Mixed vegetables*	2.6	5.5	31.7	10.0	11.7
Other vegetables	6.5	4.8	8.2	-	5.7
Subtotal	17.4	22.4	53.5	10.0	27.7
D. Mixed crops					
Fruit and grasses	6.1	11.3	0.7	4.3	6.7
Fruit and vegetables	0.9	2.6	-	16.4	3.0
Subtotal	7.0	13.9	0.7	20.7	9.7
E. Fallow land	9.5	9.8	18.8	22.1	13.3
Grand total	100	100	100	100	100

* In Salalah plains, a large number of vegetables are grown and farmers try to grow them in very small plots, so small that sometimes it is difficult to measure the area under them. Such plots are shown in the category of mixed vegetables.

* Source : FAO Report, 1991

(6) Agricultural production in Salalah

i) The Governorate of Dhofar cultivates only about 3% of the total farmed area in Oman, fruit trees occupy about 28%, field crops 21%, vegetables 28% and other crops about 10%. Dhofar occupies only 2 % of the national area of fruits, 3.5% of the field crops, 2.5 % of all vegetables and 5 .5 % of other crops.

Table A-8.1.4 Distribution of the cultivated area and production by Region (1989)

District	Area under					Total
	Fruits crops	Field crops	Vegetables	Other crops	Total area	production
	%	%	%	%	%	%
North Batinah	28	16	22.5	37	27	22.5
South Batinah	35	19.5	28	26	30	24
Sharquya	15	22	16.4	11	16	18.6
Wousta	3	5	5	5	4	4.4
Dakahlia	8	19	13	7.5	10	14
Dahira	9	15	12.6	8	10	12
Dhofar	2	3.5	2.5	5.5	3	4.5
Total	100	100	100	100	100	100
% of total area	60	16	11	13	100	100

ii) Salalah produces about 7.5% of the total vegetable production of Oman, on 2.5% of the total area planted with vegetables. The South Batinah produces 20%, on only 28% of the total area planted with vegetables. Although the composition of vegetables is not presented, it can safely be concluded that there are significant differences in productivity between Dhofar and the South Batinah.

C-2. Socio-economic conditions

(1) Family members of farmers in Salalah

Family size of the surveyed farmers' households in Salalah is about 8.

Table A-8.1.5 Family Members of Farmers in Salalah

Items	Family members			Number of persons engaged in farming			
				Family		Hired	
	Male	Female	Total	Male	Female	labors	Total
Average	4.2	3.9	8.1	0.3	0.1	2.6	3.1
Max.	10	6	15	3	2	5	9
Min.	1	0	2	0	0	1	1

Main jobs in the surveyed farmers' households are officials - 14 persons in 5 households; office workers - 16 persons in 7 households; employer, business man, teacher, police man, fireman, engineer, merchant, student and no job - 2 persons. The farming practice in the area is such that the land owner carries out the supervision of the day to day work, while the actual work is performed by permanent expatriate labors.

(2) Off-farm income and living standard of farmers

Off-farm annual income of the surveyed farmers' households, as replied by only 3 farmers, range from 7,800 OR to 10,800 OR, while the average off-farm income amounted to 10,000 OR per year in the FAO report.

The annual living expenditure of the surveyed farmers, as replied by 8 farmers, range from 4,224 OR to 8,820 OR. and the surveyed 19 farmers are thinking that most of them belong to a "middle class" in the country. And the ideal (or anticipation) of their annual incomes, as replied by 8 farmers, ranged from 7,800 OR to 42,000 OR.

Table 8.1.6 Farmers Intention on Living Standard of their Households in Salalah

Standard	High			Average			Low	Total
	High	Average	Low	High	Average	Low		
Number of households	2	0	0	3	11	3	0	19

It is very likely that the recorded off-farm income is underestimated, considering that households are in general very wealthy as mentioned in the FAO report.

C-3. Farming in Salalah

(1) Type of farming

The farming types of 19 farmers among to 20 surveyed farm households are shown in the table below.

Table A-8.1.7 Type of Farming in Salalah

Type of farming	crops	Livestock	Number of Farms
Simplified farming	Vegetables	-	1
	-	Cattle	3
	-	Various livestock	4
Diversified farming	Vegetables	Cattle	2
	Vegetables	Various livestock	4
	Vegetables	Chicken	1
	Fruits	Various livestock	1
	Vegetables & fruits	Cattle	1
	Vegetables & fruits	Various livestock	1
	Vegetables & tea	Various livestock	1
Total			19

The farming types of the surveyed farms are classified into 3 categories, namely simplified farming of vegetables - one farmer; simplified farming of livestock - 7 farmers; and diversified farming with vegetables, fruits and livestock - 11 farmers.

(2) Hired labors

The actual farming work is performed by permanent expatriate labors, whom the surveyed farmer employs and number of foreign workers vary from 5 expatriates in maximum and one expatriate in the small farm household. The total number of permanent labors of the 18 surveyed farm households is 47 persons, consisting of 27 Indians,17 Pakistanis, 2 Bangladeshis and an Egyptian.

Annual labor cost in the 16 surveyed farm households is 1,400 OR in maximum, 480 OR in minimum and 845 OR in average. And the two surveyed farm households pay 50% or 25% of the farming income to the labors.

(3) Land tenure and area under farm management

Table A-8.1.8 Farm Land Ownership of the Surveyed Farmers in Salalah

Ownership	Items	Number of households	Management area (ha/household) Average	Max.	Min.
			ha	ha	ha
Private land		10	-	-	-
	Farm land area	-	3.5	7.6	1.3
	Cultivated area	-	3.3	7.6	1.1
Leased land		10	-	-	-
	Farm land area	-	2.1	5.5	0.6
	Cultivated area	-	2.0	5.5	0.6
Total		19	-	-	-
	Farm land area	-	2.9	7.6	0.6
	Cultivated area	-	2.8	7.6	0.6

Land ownership patterns and tenurial arrangements of the 19 surveyed farms are privately owned land - 9 farms, leased land only - 9 farms and privately owned and leased land - one farm.

Table A-8.1.8 shows that average area under farm management and actually cultivated area of each farm is 3.5 ha and 3.3 ha in the privately owned land, and 2.1 ha and 2.0 ha in the leased land, respectively. Annual rent of leased land is 340 OR per feddan (0.42 ha).

And area under management per farm household of the 19 surveyed farms is 7.6 ha in maximum, 0.6 ha in minimum and 2.9 ha in average, respectively.

The FAO report showed in detail on the land tenure in Salalah Plain as mentioned below.

Several land tenure arrangement can be distinguished.

-1 Most land is privately owned and operated by owner. Around 59% of area is under owned and self operated class.

-2 Leased-out and leased-in land is more practiced by land owners of size class 3 to 7 feddan. The leased land are given either on fixed rent or share cropping. Sharecropping is foremost limited to annual/seasonal crops, especially vegetables.

-3 The other for tenure is contract farming. The payment is made for renting the land, and for the use of existing irrigation facilities including the pump (s), as well as the available farm premises. Contract farming might occur both on owned as well as on Awqaf.

-4 There is a form of land tenure called "Awqaf". This land belongs to the Ministry of

Justice, Awqaf & Islamic Affairs. Awqaf land was usually distributed among the poor people at a nominal fee. The usufruct (right of use) of this land is passed on their heirs, regardless of the status of their income and well-being. However, to let benefit as many people as possible, only relatively small areas were distributed resulting in an average farm size of less than 3 feddan (1.3 ha). Of all farms in the survey, about 10 % is Awqaf land.

(4) Irrigation

Water resources of the surveyed farms, as replied by 16 farmers, are deep wells in 9 farms, shallow wells in 5 farms and free flow - 2 farms.

Two farms are irrigated by furrow irrigation and modernized irrigation (with sprayers) and the others are irrigated by traditional (furrow) irrigation.

Pumping for irrigation, as replied by 8 farmers, is driven with diesel engines in 6 farms and with electric engines in 2 farms.

With regard to quantity and quality of irrigation water, as replied by 5 farmers, quantity of water is enough in all farms and quality of water is bad in one farm and good in the rest. Summarization of the FAO report on this paragraph is as follows;

-1 In Salalah plain Government policies of price support and subsidies to the livestock sector have induced change in the land use. These policies have encouraged the expansion of area under banana and grasses which have high water requirements thus further deteriorating the aquifer water balance.

-2 Among the physical constraints in the study area climate, soils and water quality (salinity) are the most important. The study has shown that about 34 % of the cultivated area is irrigated with brackish water having an electrical conductivity between 3 and 15 ds/m.

(5) Cropping

Cultivated crops and number of farms cultivated each crop in the surveyed farms are as follows;

Vegetables : Tomatoes/7 farms, cucurbits/4 farms, pepper/3 farms, chili/1 farm, okra/1 farm
Fodder crops : Rhodes grass/12 farms, alfalfa/1 farm
Fruits and other trees : Banana/3 farms, coconut/2 farms, papaya/2 farms, lemon/1 farm and tea/1 farm

Cropping seasons of vegetables are as shown in the table A-8.1.9.

Table A-8.1.9 Cropping Season in Salalah

Crops	Seeding time		Harvesting time	
	from	to	from	to
Cucumber	September	December	December	March
Tomato	June	August	September	November
Pepper	November	December	February	March
Rhodes grass	July	August	every 40-60 days	

(6) Herding of livestock

-1 Number of livestock and production costs

Number of livestock of the surveyed farm households, which are replied by 17 farmers, are as shown in the table below.

Table A-8.1.10 Number of Livestock per Household

Kind of livestock	Number of households raising livestock	Number of livestock / household		
		Average	Max.	Min.
	Households	heads	heads	heads
Cattle	13	24.9	67	8
Sheep	6	43.0	85	22
Goat	11	36.7	120	8
Chicken	5	1,070.0	3,000	50

The 13 farmers of the 17 surveyed farmers raise cattle for milk and meat. The number of cattles in each farm household is 67 heads in maximum, 8 heads in minimum and 25 heads in average. And sheep and goats are raised by 6 and 11 farmers and number of sheep and goats in each farm household is 43 heads and 37 heads in average. Chicken is raised by 5 farm households and number of chicken in each farm household is 1,070 in average.

Farm-gate prices are 250 to 300 OR per head of cattle, 20 to 35 OR of sheep, 20 to 40 OR of goat and 0.7 to 1 OR of chicken per head.

-2 Hay

Most farmers of 13 farm households who raise cattle cultivate Rhodes grass. Among them 9 farmers do not have enough hay and the rests have enough. Six of the 9 surveyed farmers are in shortage of hay and intend to purchase hay continuously, and expect 0.5 O.R./bale as a reasonable purchase price which is half of the prevailing price.

On the other hand, 2 farmers of the 13 surveyed farmers have a intention to sell hay.

C-4. Farmers' intention for farming and living

(1) Farmers' intention to keep up farming

Replies on intention to keep up farming is obtained from 16 farmers of the 20 surveyed farmers. The 15 farmers of them intend to positively keep up farming and the rest intend to keep if they get the agricultural credit in succession. The reasons of keeping up farming are that farming generates a good income or produces foods for home consumption.

Successors of farming as supervisor for permanent labors of expatriates are kept in the 12 farm households of the 15 surveyed farmers which replied to the question on presence of successors.

(2) View on increase of income

With regard to the ways to increase family income in near future, as replied by the 10 surveyed farmers, 4 farmers intend to increase income by agriculture, such as expansion of farm land, yields of crops, introduction of new crops and cattle and new irrigation facilities. The others intend to increase income by non-agriculture, such as employment of office worker and pension.

(3) View on agricultural credit and subsidies

The 3 farmers expressed their discontents about agricultural credit as below;

-1 Repayment of the credit is difficult, because of high interest of credit.
-2 There is no merit of credit for farmers, because of the cheap buying price of agricultural products by public marketing agency.
-3 Repayment of the credit is difficult in case of an unforeseen accident.

(4) View on agricultural extension works

The 16 of the 17 replied farmers are satisfied with the present extension activities of the extension centers. The rest expects still more to increase the counseling on farming techniques. However, even in the satisfied farmers, they have the expectation of increasing the counseling, the exhibition plot of new farming techniques, expansion of subsidy activities, such as improvement of lease of farm machinery, raise of the rate of subsidy, etc.

Summarization of the FAO report on agricultural extension works is as follows;

-1 In the whole country there are 9 regional offices and 45 extension centers. 5 extension centers are located in the Governorate of Dhofar. The regional office is headed by one supervisor, under his direction 6 extension officers (50% are expatriates) render services to the farmers. In the whole country there only 10 subject matter specialists. Of these, none are stationed in Salalah.

-2 Plant protection activities are carried out by one engineer who is aided by 2 plant protection assistants. In total, there are 12 teams in Dhofar for the spraying of insecticides and one statistician assisted by 4 enumerators.With only 796 smallholders in the Salalah plain the extension officer/farmer ratio is relatively high when compared with other parts of the country.

-3 Activities of extension centers : visited regularly by the extension officers (about 5 to 7 farmers in a day), visiting the extension center themselves for advice, group meeting in which audio-visual techniques used, on-farm demonstrations.

-4 The extension service plays an important role in assisting new farmers in establishing their 5 to 10 feddan new farms. In 1987 the Government launched a program to establish 2,500 new farms in the country.

-5 The extension officers are in charge of the distribution of seeds, fertilizers and pesticides, while they also carry out spraying programs after field inspection. The farmer does not pay for the labor costs, while the pesticides are provided at 50% of the real cost. In most cases, the farmer is visited after the farmer has made a request for the supply of inputs. After substantiation, the farmer receives a voucher and can collect the approved inputs at reduced rate from certain companies.

-6 All farm mechanization activities are performed by the tractor fleet of the extension centers at a subsidized rate of one OR per hour. At peak periods, the rate is unofficially raised to 2 OR per hour to cover payment of overtime to the drivers.

(5) Expectation from the Government

Expectations from the Government of the 12 surveyed farmers are as shown in the following table.

Table A-8.1.11 Expectation of Farmers from the Government

Items of farmers' expectation for Government	Number of households
Private ownership of farm land	7
Grant-in-aid for buying farm machinery	7
Grant-in-aid for livelihood improvement	6
Improvement of agricultural credit	5
Grant-in-aid for building storehouse of products	5
Construction of irrigation facilities	4
Preparation and maintenance of rural infrastructure (especially electric supply)	4
Grant-in-aid for building processing facilities	3
Grant-in-aid for building market	2

The main items greatly expected by the surveyed farmers in Salalah are the promotion of private ownership of farm land, grant-in aid for buying farm machinery, grant-in aid for livelihood improvement, improvement of agricultural credit and grant-in aid for building storehouse of products, etc.

Appendix 8-2 Results of Questionnaire Survey of Herders in Jabal (Mountain Area)

A. Purpose of the survey

At present, Rhodes grass is produced in NARS as the reclamation crop and has potential to become one of the main crops in future. The purpose of this survey is to clarify the prospect of hay production by means of surveying the Jabal's herders as purchaser of hay, and to clarify the possibility of the circulation between herders in Jabal and hay producers in Nejd.

B. Methods of the survey

1) Time of survey: September to December, 1995
2) Location: Jabal in Dhofar
3) Sampling size: 21 herders
4) Survey methods: Interview

C. Results of the survey

C-1 Family members of herders in Jabal

The average family size in Jabal is about 11. And average number of family persons engaged in herding is four, namely two men, one woman and a hired labor (Table A-8.2.1).

According to the Travers Morgan's Report (" Detailed land use study in Jabal Dhofar", Vol.3, 1994), tribal origin and affiliations are important amongst the Jabalis, especially in matters relating to land, grazing and settlement rights. The majority of Omani population in the survey area is Jabali by descent, language, custom and self identity. The small number of non-Jabalis are mostly government employees, some traders, or have married with Jabali families. Most of them are from within Dhofar, especially from area around Salalah.

C-2 Number of livestock in each herder

Number of cattle in each herder is 18 heads of calves, 13 heads of immature cattle, 49 heads of matured cattle and 81 heads in total. Birth rate of cattle and number of sold cattle is very low, and number of dead is high. These suggest poor cattle management and poor marketing of cattle (Table A-8.2.2). According to the Travers Morgan's Report, livestock ownership is as follows;

Livestock ownership in Jabal is classified into 8 categories, such as cattle only - 56 % of whole herders in Jabal, cattle and camel - 16 %, cattle and goats - 6 %, camel and goats - 8 %, camel only - 10 %, camel and goats - 5 %, respectively. Category of our surveyed herders is "cattle only".

According to the Travers Morgan's Report, traditional herders' lives revolved around and focused on their livestock, upon which they were reliant for food and survival. It is clear that livestock are not kept with only one objective, 77 % of the respondents claim to keep livestock for traditional reason, which include subsistence of the family. Liquid milk is not a commodity for sale, although some of the ghee made from cows milk is sold. Meat is a less important product than milk. The main output from the livestock is milk. More cow milk is now produced and consumed. This used to involve the slaughter at birth of nearly all male cattle and camels. Lately this has been modified and young male cattle are fed up to salable weight and sold to traders who export them to northern Oman, and to butchers in Salalah.

C-3 Location of vegetation in cattle grazing by season

Cattle grazes mainly at plain and evergreen wood land in Khareef (July to September), at plain, evergreen wood land and grass land in Serb (October to December), at grass land in Shita (January to march) and Qayd (April to June). These suggest that range land in Jabal is hardly available from Shita to Qayd (from January to June) for grazing (Table A-8.2.3).

C-4 Range land management

Growth of vegetation in range land have decreased very deeply in comparison with 10 years ago. The present use of range land is over grazing, because rain is less and rain season is not uniform, and number of cattle increases due to poor livestock market to sell.

C-5 Amount of supplementary feeds in each herder's household by season

Quantities of concentrates, hay and sardines (kg/adult equivalent/day) are 2.0 kg, 1.9 kg and 1.2 kg in yearly average (Table A-8.2.4 and A-8.2.5). These data are nearly same with the data of the Travers Morgan's Report.

Daily amount of supplementary feeds is different by season. Concentrates are supplied more in Shita and Qayd than other seasons. Sardines are supplied in Serb and Shita only.

Daily quantities of hay in Khareef, Serb, Shita and Qayd per head in adult equivalent are 1.5, 0.6, 1.2 and 3.8 kg/adult equivalent head/day, respectively. Amount of fed hay is the most in Qayd, followed by Khareef. Therefore, the demand for hay is the most and the unit price of hay is the highest in Qayd (April to June).

Sardines are traditional and valuable source of crude protein. They are fed mostly in Shita, but feeding may start in November. This coincides with the decline in protein levels in the range grazing.

C-6 Herders' intention on purchased hay

Quantity of hay for raising cattle is very short in the whole surveyed herders. Hay is purchased at farmers' garden (76 % herders of whole surveyed herders) or from traders'

lorries at herders' garden (100 % herders of whole surveyed herders).

Purchased hay is produced in Salalah, Nejd and northern area of Oman (Muscat). Before three years, hay had been purchased from Saudi Arabia, but now it is home products only.

Percentage of herders who use hay produced at Salalah, Nejd and Muscat are 95 %, 65 % and 90 %, respectively. And hay produced at Salalah, Nejd and Muscat are appreciated by 95 %, 32 % and 0 % of herders for the best quality, respectively.

81 % of surveyed herders want to purchase hay continuously in the future, if funds are available.

Troubles in feeding the purchased hay include loss due to deterioration caused by high moisture in Khareef (38 % of herders), high price of hay (29 %) and low supply of hay after Shita (0.5 %).

The surveyed herders expect 0.5 R.O./bale as a reasonable purchase price for hay which is half of the prevailing price.

C-7 Cattle feces treatment

The duration for which the cattle are kept in the byres, where resource of compost is produced, by the age of cattle are shown in Table A-8.2.6. The duration of cattle kept in the byres are 13 months for calves during four seasons, 4 months for immature and matured cattle in Khareef. The reasons for keeping in the byres are to protect from troubles for calves, to protect from cold and damage from biting flies in Khareef.

With regard to way of making compost, after drying and packing in bags, manure is sold in the herder's garden to traders. Periods of drying are usually one or two weeks. Sometimes manure is sold as in wet and then dried by traders. Drying and packing are done by labors.

Amount of compost sold by each herder is as shown in Table A-8.2.7. Herder's yearly income by sale of compost is 1,500 R.O. in maximum, 80 R.O. in minimum, and 506 R.O. in average.

The rest of the feces which were not sold are used to make smoke to prevent the biting flies' attack on cattle in Khareef and used as bed for calves. Some herders sold all of feces.

With regard to constraints about cattle feces treatment, herders can not dry and collect feces due to fog and rain in Khareef. And another problem is low price of compost.

Compost is so eagerly sought after by the traders that sometimes compost is sold when it is wet, and herders want to sell the compost though the price of produced compost is low.

C-8 Migration of herders in Jabal

It is generally known that herders' families in Jabal moved every season until 10 years ago, but now the majority of families stay in their residences throughout the year. According to the results of our survey, however, 62 % of surveyed herders moved to Jerbeeb (plain at base of Jabal) in Qayd (April to June) and 48 % 0f herders moved to Jerbeeb in Khareef (July to September).

C-9 Way to avoid the biting flies

Biting flies' attack on cattle is a big problem. The problem of biting flies occurs from the beginning of Khareef to the end of Serb, and the peak of damage occurs mainly in the last month of Khareef.

Herders are used to keep cattle in the byres during daytime to avoid the biting flies' attack, and to make smoke by use of cattle dry feces. Wali office sometimes sprayed pesticides but could not prevent perfectly.

C-10 Watering for cattle

There are one to five Government's troughs in the range land which can be used by each herder. Numerous troughs have been established and geographically well spread. Number of trips in a day for watering for cattle are three in average, six in maximum, and hours spent for watering in a day are 2.4 hours in average.

C-11 Income and expenditure of herders' household

Income, expenditure and balance in the surveyed herders' household are shown in Table A-8.2.8. Herders' household finances are in deficit in all surveyed herders. It was not available to clarify how the deficit is covered by each herder.

The rate of living expenditure and input cost for herding for total expenditure in herders' household are about 20 % and 80 %, respectively. And rate of concentrates' cost, hay cost and sardines cost for all input cost for herding are 46 %, 38 % and 10 %, respectively.

D. Conclusion

Constraints in livestock management of herders in Jabal are as follows;

1) Objectives of herding cattle in Jabal are mainly milk for home consumption, not meat production for sale. Herders in Jabal have no intention of selling meat and livestock products by nature.

2) Livestock and livestock produce marketing are poor. Therefore, the number of cattle will increase inevitably by multiplier effect of herders' intention and poor marketing.

3) As a result of increase of cattle, range land deterioration has been induced by overgrazing and lower rainfall in Khareef lately, and the cost of supplementary feed in herding household, especially purchased hay, has increased. Herders' management are pressured by these feeding costs.

4) However, 81 % of surveyed herders want to purchase hay continuously in the future if funds are available. And the surveyed herders expect 0.5 R.O./bale as a reasonable purchase price of hay which is half the prevailing price. On the other hand, about 20 % of surveyed herders don't want to purchase hay in the future.

5) Hay producers should make efforts to supply more quantity in Qayd, higher quality of hay in all seasons and more cheap hay. On the other hand, herders should have a good idea to prevent the loss of hay due to deterioration caused by high moisture in Khareef.

6) Compost is so eagerly sought after by traders that sometimes cattle feces is sold as it is wet, and herders want to sell the compost to earn money which is equivalent to yearly labor's cost. Therefore, it is difficult to circulate between compost of herders in Jabal and hay of producers in Nejd to increase the fertility of soil, because both of compost and hay are marketable goods.

7) The only solution for constraints of herding management in Jabal is the marketing development of cattle, including export of live cattle and livestock produces.

Table A-8.2.1 Family members of herders in Jabal

Items	Family members			Number of persons engaged in herding			
				Family		Hired	
	Male	Female	Total	Male	Female	labors	Total
Average	5.1	5.5	10.6	1.9	1.3	0.9	4.1
Max.	14	9	23	4	3	1	8
Min.	1	2	3	1	0	0	1

Table A-8.2.2 Number of livestock in each herder in Jabal

Kind of livestock	Items	Number of herds in 1994	Production in 1995		
			Birth	Sold	Dead
		heads	heads	heads	heads
Calves	Average	18.3	5.8	9.1	1.0
	Max.		27	15	4
	Min.		0	3	0
Immature cattle	Average	12.8	-	3.5	0.2
	Max.	-	-	8	3
	Min.	-	-	1	0
Mature cattle	Average	49.4	-	6.7	1.8
	Max.	-	-	17	7
	Min.	-	-	4	0
Total	Average	80.6	5.8	14.8	3.0
	Max.	151	27	36	9
	Min.	40	0	7	0

Note: Four herders of 21 herders consumed six cattle in all as beef at home.

Table A-8.2.3 Location of vegetation in cattle grazing by season

Vegetation types	% of herders used each range			
	khareef	serb	shita	qayd
	%	%	%	%
Plain	86 *	38 *	19	14
Dry wood land	0	0	10	5
Deciduous wood land	14	19	14	14
Evergreen wood land	67 *	57 *	19	14
Shrub zone	0	10	10	10
Grass land	10	67 *	67 *	57 *
Short grass land	0	5	5	10

Table A-8.2.4 Amount of supplementary feeds in each herders' household by season

Cattle feeds purchased	Items	Supplementary feeds by season							
		khareef		serb		shita		qayd	
		bags/day	kg/day	bags/day	kg/day	bags/day	kg/day	bags/day	kg/day
Concentrates	Av.	2.1	105	2.3	115	3.1	155	3.6	180
	Max.	5	250	5	250	6	300	7	350
	Min.	1	50	1	50	2	100	2	100
Hay		bales/day	kg/day	bales/day	kg/day	bales/day	kg/day	bales/da	kg/day
for calves	Av.	3.4	44.2	3.5	45.5	4.5	58.5	5.7	74.1
	Max.	7	91	10	130	30	390	50	650
	Min.	2	26	2	26	2	26	2	26
for other cattle	Av.	5.2	67.6	0	0	2.3	29.9	15.6	202.8
	Max.	30	390	0	0	10	130	40	520
	Min.	0	0	0	0	0	0	0	0
		bags/day	kg/day	bags/day	kg/day	bags/day	kg/day	bags/day	kg/day
Sardines	Av.	0	0	3.7	148	4.3	172	0	0
	Max.	0	0	10	400	10	400	0	0
	Min.	0	0	0	0	0	0	0	0

Table A-8.2.5 Daily amount of supplementary feeds by seasons

Cattle feeds purchased	Daily amount per head by season				Average (year)
	khareef	serb	shita	qayd	
	kg/a.e./day	kg/a.e./day	kg/a.e./day	kg/a.e./day	kg/a.e./day
Concentrates	1.6	1.7	2.3	2.7	2.0
Hay	1.5	0.6	1.2	3.8	1.9
Sardines	0.0	2.2	2.5	0.0	1.2

Note: Average number of cattle in adult equivalents in surveyed herder's households was 67.6 heads. a.e.: adult equivalent

TableA-8.2.6 Periods kept cattle in byres by age

Age of cattle	Periods kept in byres			Reasons of keeping in the byres
	Season	Months	Range	
		months	months	
Calves	4 seasons	13.5	24~12	Protection from troubles.
Immatur	khareef	4.6	7~1	Protection from cold and damage from biting
mature	khareef	3.8	61	flies in khareef and no grass in range land

Table A-8.2.7 Amount of compost sold by each herder

Items	Compost sold for one year			Unit price
	bags/year	ton./year	R.O./year	R.O./bag
Average	3065	36.8	506	0.15
Max.	6000	72	1500	0.20
Min.	400	4.8	80	0.10

Note: One bag contains 12 kg of compost.
Retail price is 0.575 R.O./bag of 35 kg (0.2 R.O./12 kg).

Table A-8.2.8 Income and expenditure of herders' household

Items	Unit	Average	Max.	Min.
Income				
1. Livestock sale				
1) Calves	heads	9	15	3
Unit price	R.O.	99	190	75
2) Immature	heads	4	8	1
Unit price	R.O.	118	150	90
3) Mature	heads	7	17	4
Unit price	R.O.	203	280	150
Livestock sale of each herder	R.O./year	2,086	4,680	720
2. Produce sale				
1) Cow's milk	ton/year	8	18	0
Unit price	R.O./liter	0	0	0
Income	R.O./year	1,100	2,160	0
2) Ghee	bottle	202	360	48
Unit price	R.O./bottle	4	5	4
Income	R.O./year	876	1,800	192
3) Compost	12kg-bags/year	3,065	6,000	400
Income	R.O./year	506	1,500	80
Produce sale of each herder	R.O./year	1,939	4,200	0
3. Non-livestock income				
1) Firqat	R.O./year	1,043	264	0
2) Civil service	R.O./year	1,531	5,400	0
3) Trade	R.O./year	197	1,980	0
4) Allowance	R.O./year	80	600	0
Non-livestock income of each herder	R.O./year	2,851	5,400	1,500
4. Total income	R.O./year	6,876	11,380	2,600
Balance	R.O./year	-5,161	-584	-14,502

Items	Unit	Average	Max.	Min.
Expenditure				
1. Input cost for herding				
A. Supplementary feeds				
1) Concentrates (bags)	bags/year	1,011	1,980	540
Unit price	R.O./50kg-bag	4	4	4
Cost	R.O./year	4,400	8,613	2,349
2) Hay				
(1) in khareef (bales)	bales/3 months	778	2,970	180
Unit price	R.O./bale	1	1	1
Cost	R.O./3 months	677	2,970	180
(2) in serb (bales)	bales/3 months	319	900	180
Unit price	R.O./bale	1	1	1
Cost	R.O./3 months	290	900	126
(3) in shita (bales)	bales/3 months	615	2,700	180
Unit price	R.O./bale	1	1	1
Cost	R.O./3 months	608	2,700	162
(4) in qayd (bales)	bales/3 months	1,916	4,500	720
Unit price	R.O./bale	1	2	1
Cost	R.O./3 months	2,126	5,850	864
Hay cost of each herder	R.O./year	3,701	10,487	1,620
3) Sardines	40kg-bags/year	720	1,800	0
Unit price	R.O./bag	1	2	1
Cost	R.O./year	996	2,340	0
Feed cost of each herder	R.O./year	9,096	18,351	5,544
B. Labor cost	R.O./year	557	720	0
C. Livestock purchases	R.O./year		850	0
Input cost of each herder	R.O./year	9,653	19,921	5,544
2. Living expenditure				
1) Electricity	R.O./year	450	1,500	0
2) Food	R.O./year	1,052	2,400	320
3) Schooling	R.O./year	250	500	0
4) Petrol etc.	R.O./year	555	1,000	0
5) Water	R.O./year	70	700	0
6) Others	R.O./year	7	150	0
Living expenditure of each herder	R.O./year	2,334	3,900	520
3. Total expenditure	R.O./year	12,037	21,631	7,029

Appendix 8-3 Results of Questionnaire Survey of Herders in Nejd

A. Purpose of the survey

At present, Rhodes grass is produced in NARS as the reclamation crop and has potential to become one of the main crops in future. The purpose of this survey is to clarify the prospect of hay production by means of survey of Nejd's herders as purchaser of hay, and to clarify the research tasks in NARS.

B. Methods of the survey

1) Time of survey: December, 1995
2) Location: Nejd in Dhofar
   Modhay, Rawyah, Habroot, Thahboor, Shisur and Thamrite in Nejd-subregion
3) Sampling size: 17 herders
4) Survey methods: Interview

C. Results of the survey

The current total population in Nejd is estimated at about 7,400 people. It is generally known that there are many herders who raise goats and camels in Nejd, and the number of them reaches about 70 % of the whole households engaged in herding and farming in Nejd. According to the survey of the Extension Center, Salalah, 1995, the number of farm household in Nejd was 195. Therefore, it is estimated that the number of herders in Nejd is about 500 households. The survey was carried out on 17 herders of about 500 herders' households in Nejd. The results of survey are as follows;

C-1. Family members of herders in Nejd

The average family size of herders' households in Nejd is 11. The average number of family members engaged in herding is four, namely two men and two women, and labors for herding were hired by only 3 herders of 17 surveyed herders in Nejd (Table A-8.3.1).

C-2. Number of livestock in each herder

Average number of livestock in each herder is one head of male goat, 57 heads of female goats, one head of male camel, 34 heads of female camels, respectively (Table A-8.3.2). Four herders of the seventeen surveyed herders raise camels only and others raise camels and goats.

Average birth rate of goats and camels for each total female are 27 % and 25 %, respectively. Rate of sold goats and camels for each total livestock are 17 % and 10 % in average, and average mortality rate of goats and camels are 6 % and 0.9 %, respectively.

Four herders of the seventeen surveyed herders consumed one to three goats as meat at each home in 1995.

C-3. Livestock grazing and watering

There are two types of livestock herding, leaving free and keeping in cage. In Nejd, goats are raised in cage all day long in most cases. On the other hand, camels are raised in cage or left free, 47 % of the 17 surveyed herders are in the first category and 53 % are in the later (Table A-8.3.3).

In case of leaving camels free, a herder shifts with camel traveling to range land which is 25 km to 10 km away from home and is in condition of over grazing at present.

8 of the 17 surveyed herders supply water to livestock from home well, 3 herders supply by tanker 10 to 15 times per month, and 6 herders take trip one time a day for watering of livestock.

Herder who cultivates fodder crops is only one in the surveyed herders. Therefore, livestock in Nejd has to depend on supplementary feeds and range land far away from home for feeding in most cases.

C-4. Amount of supplementary feeds in each herder's household by season

Quantities of concentrates (kg/adult equivalent/day/ household) are about 30 kg in summer, 28 kg in winter for goats and 83 kg in summer, 29 kg in winter for camel in average. Quantities of hay (kg/adult equivalent/day/ household) are about 19 kg in summer, 18 kg in winter for goats and 43 kg in summer, 19 kg in winter for camel in average, respectively (Table A-8.3.4).

Daily amount of supplementary feeds per head changes with season. Concentrates are supplied 0.4 kg /head /day in summer, 0.4 kg in winter for goat and 2.4 kg in summer, 0.9 kg in winter for camel in average. Daily quantities of hay in summer and winter per head in adult equivalent are 0.2 kg in summer, 0.2 kg in winter for goat, and 1.2 kg in summer, 0.5 kg in winter for camel in average (Table A-8.3.5).

Amount of fed hay is the most in summer. Therefore, the demand for hay is the most and the unit price of hay is the highest in summer. Besides these concentrates and hay, one of the surveyed herders feed camels with sardines in summer and with wheat throughout the year.

C-5. Herders' intention on purchased hay

Quantity of hay used for raising livestock in Nejd is very low in all the surveyed herders. Hay is purchased at produced farmers' garden or market (59 % of the surveyed herders) or from traders' lorries at herders' garden (76 % of the surveyed herders).

Purchased hay is produced at Nejd, PDO farm in Marmul and northern area of Oman (Sohar).

Percentage of herders who use hay produced at Nejd, Sohar and Marmul are 94 %, 53 % and 13 %, respectively. And hay produced at Nejd is appreciated by 94 % of herders as the best quality.

The whole surveyed herders want to purchase hay continuously in the future if funds are available. No herder expressed troubles in feeding the purchased hay.

The surveyed herders expect 0.5 R.O./bale as a reasonable purchase price for hay which is half of the prevailing price.

C-6. Migration of herders in Nejd

According to the results of our survey, 47 % of the surveyed herders, not accompanied by their families, shift with camels traveling to range land.

C-7. Raising camels for race

Five herders of the surveyed herders have one to three camels for race. Raising cost of a racing camel was 600 to 1,200 R.O. per year in 1995. One herder sold two racing camels at a rate of 500 R.O. /Camel in 1995.

C-8. Farming

Eight of the surveyed herders have private wells and cultivate vegetables, fodder crops and dates. Total field area of each herder's household is 12 ha in maximum, 0.25 ha in minimum and 3.2 ha in average, but the cultivated area is 2 ha in maximum, 0.25 ha in minimum and 1.1 ha in average in 1995.

There are five farming types in the surveyed herders' households, such as vegetables only - one herder, vegetables and dates - one herder, dates only - four herders, fodder crops only - one herder and fodder crops and dates - one herder.

In 1995, there was only one herder who produced and sold two to five tons of water melon, sweet melon, cucumber and coosa with 2,400 R.O. of yearly production cost for all the vegetables, and got income of 3,500 R.O. Other herders' farm products were consumed at their home (Table A-8.3.6).

C-9. Income and expenditure of herders' household

Income, expenditure and balance of the surveyed herders' household are shown in Table A-8.3.7. Herders' household finance was in the deficit of about 1,200 R.O.in average. It was not available to clarify how the deficit is covered by each herder. In 1995, the balance in the surveyed herders' households was 2,453 R.O. in maximum and - 6,992 R.O. in minimum.

The rate of livestock sale for total income was 16 % and the income of each household depended on the non-livestock income, such as wages of firqat and civil services. The percentage of living expenditure and input cost for herding in total expenditure in herders' household was about 38 % and 62 %, respectively. And rate of concentrates cost and hay cost in total input cost for herding were 65 % and 35 %, respectively.

D. Conclusion

The results of the survey with the seventeen herders in Nejd were summarized as follows;

1) Most herders in Nejd raise goats of about 60 heads and camels of about 35 heads.Livestock is raised mostly by family labors, and few herders hire labors.

2) Goats are raised in cages all day long in most cases in Nejd. On the other hand, camels are raised left free in half herders or in cage. In case of leaving camels free, a herder shifts with camel traveling to range land which is 25 km to 10 km away from home and is in condition of over grazing at present. Therefore, raising of all goats and camels in the surveyed herders mostly depend on the purchased supplementary feeds, except grazing at range land in half of the herders' households.

3) Concentrates are supplied at a rate of 0.4 kg /head /day for goat throughout the year and 2.4 kg in summer, 0.9 kg in winter for camel. Daily quantities of hay in summer and winter per head in adult equivalent are 0.2 kg for goat throughout the year, and 1.2 kg in summer, 0.5 kg in winter for camel in average.

   Amount of fed hay is the highest in summer. Therefore, the demand for hay is the highest and the unit price of hay is the highest in summer. Herders expect 0.5 R.O./bale as a reasonable purchase price for hay which is half of the prevailing price. And hay produced at Nejd is appreciated as the best quality.

   Quantity of hay used for raising livestock in Nejd is very short in all the surveyed herders. However, all the surveyed herders want to purchase hay continuously in the future if funds are available.

4) Half herders of the surveyed herders have the own wells for watering of livestock and for farming. In an average, the surveyed herders have about one ha of field and cultivate vegetables and dates for home consumption.

5) With regard to farm household economy, the income of each household depended on the non-livestock income, such as wages of firqat and civil services, and the rate of livestock sale to total income was 16 % only. The rate of living expenditure for the total outgo in the surveyed herders' households was about 40 % and the rest was the input cost for herding. The input cost of herding consisted of concentrates cost of 65 % and hay cost of 35 %.

6) The only solution for overcoming the constraints in herding management in Nejd is the marketing development of livestock.

Table A-8.3.1 Number of family members of herders in Nejd

Items	Family members			Number of persons engaged in herding			
				Family		Hired	
	Male	Female	Total	Male	Female	labors	Total
Average	4.4	6.9	11.3	1.8	1.8	0.2	3.8
Max.	9	12	21	4	3	1	8
Min.	1	4	5	0	0	0	0

Table A-8.3.2 Number of livestock in each herder in Nejd

Kind of livestock	Items	Number of herds (in 1994)	Production (in 1995) Birth	Sold	Dead
		heads	heads	heads	heads
Goat (Male)	Average	0.9	6.9	6.4	0.2
	Max.	3	20	20	3
	Min.	0	0	0	0
Goat (Female)	Average	57.4	8.6	3.4	3.1
	Max.	150	25	10	10
	Min.	12	0	0	0
Camel (Male)	Average	0.6	3.7	2.9	0.1
	Max.	1	10	9	2
	Min.	0	1	0	0
Camel (Female)	Average	34.0	4.8	0.7	0.2
	Max.	70	13	3	2
	Min.	6	0	0	0
Total	Average	82.6	-	13.4	3.5
	Max.	223	-	32	12
	Min.	30	-	2	0

Note: 1) Four herders in the 17 surveyed herders raise camels only and others raise camels and goats.
2) Four herders of 17 herders consumed one to three goats as meat at each home in 1995.

Table A-8.3.3 Livestock grazing

Kind of Livestock	Type of Herding	% of herders to the surveyed herders	Hours kept in cage per day Average	Max.	Min.	Location of grazing* (km from home) Average	Max.	Min.
		%	hrs/day	hrs/day	hrs/day	km	km	km
Goat	Leave free	0	-	-	-	-	-	-
	Keep in cage	100	23.1	24	12	-	-	-
Camel	Leave free*	53	-	-	-	16.7	25	10
	Keep in cage	47	16.5	24	12	-	-	-

Note 1) * In case of leaving camels free, a herder shifts with camel traveling to range land which is in the condition of over grazing now.
2) 8 herders in the 17 surveyed herders supply water to livestock from home well, 3 herders supply by tanker 10 to 15 times per month, and 6 herders take trip one time a day for watering of livestock.
3) Herder who cultivate fodder crops is only one in the 17 surveyed herders.

Table A-8.3.4 Amount of supplementary feeds in each herders' household by season

Livestock feeds purchased	Items	Goat				Camel			
		Summer		Winter		Summer		Winter	
		bags/day	kg/day	bags/day	kg/day	bags/day	kg/day	bags/day	kg/day
Concentrates	Av.	0.6	29.8	0.6	27.6	1.7	83.1	0.6	29.4
	Max.	2	100	2	100	3.5	175	2	100
	Min.	0	0	0	0	0	0	0	0
		bales/day	kg/day	bales/day	kg/day	bales/day	kg/day	bales/day	kg/day
Hay	Av.	1.5	19.0	1.4	17.6	3.3	43.2	1.5	19.1
	Max.	5	65	5	65	13	169	5	65
	Min.	0	0	0	0	0	0	0	0

Note: Besides concentrates and hay, one herder of the seventeen surveyed herders feed camels with sardines in summer and feed goats and camels with wheat throughout the year.
Summer: April ~ September, Winter: October ~ March

TableA-8.3. 5 Daily amount of supplementary feeds per head by season

Kind of livestock	Goat		Camel	
Cattle feeds purchased	Summer	Winter	Summer	Winter
	kg/a.e./day	kg/a.e./day	kg/a.e./day	kg/a.e./day
Concentrates	0.4	0.4	2.4	0.9
Hay	0.2	0.2	1.2	0.5

Note: Average number of livestock in adult equivalents in surveyed herder's households was 58.3 heads. of goats and 34.6 heads of camels.

Table A-8.3.6 Farming in Herders' Households in Nejd

Farming type	Herder's NO.	Kind of Crops	Total field area (ha)	Cultivated area (ha)	Cost R.O./year	Yield ton/year	Sale O.R./year	Home consumption
Vegetables only	1	Water melon	2	0.5	2400/	2~5	3,500/	-
		Sweet melon		0.5	4 crops	2~5	4 crops	-
		Cucumber		0.5		2~5		-
		Coosa (cassa-ba:muskmelon)		0.5		2~5		-
Vegetables & Dates	2	Tomato	1	-	600/		0	all
		Cucumber		-	3 crops		0	all
		Coosa (cassa-ba:muskmelon)		-			0	all
		Dates		-	240		0	all
Dates only	3	Dates	0.25	0.25			0	all
	4	Dates	1.5	1.5	720	3	0	all
	5	Dates	1	1			0	all
	6	Dates	2	2	1300		0	all
Fodder crop only	7	Rhodes grass	0.25	0.125			0	all
		Alfalfa		0.125			0	all
Dates & fodder crop	8	Dates	0.5	0.2	200	1	0	all
		Rhodes grass		0.3	50	10	0	all

Table A-8.3.7 Income and expenditure of herders' household

Items	Unit	Average	Max.	Min.
Income				
1. Livestock sale				
1) Goat (male)	heads	8	20	0
Unit price	R.O.	11	18	0
2) Goat (female)	heads	4	10	0
Unit price	R.O.	20	40	0
3) Camel (male)	heads	3	9	0
Unit price	R.O.	101	130	0
4) Camel (female)	heads	1	3	0
Unit price	R.O.	81	300	0
5) Camel for race	heads		2	
Unit price	R.O.		500	
Livestock sale of each herder	R.O./year	780	2,125	36
2. Produce sale	R.O./year	0	0	0
3. Farm products sale	R.O./year	0	3,500	0
4. Non-livestock income				
1) Firqat	R.O./year	1,376	5,040	0
2) Civil service	R.O./year	2,584	13,200	0
Non-livestock income of each herder	R.O./year	3,960	13,200	960
5. Total income	R.O./year	4,945	13,665	1,794

Items	Unit	Average	Max.	Min.
Balance	R.O./year	-1,151	2,453	-6,992

Items	Unit	Average	Max.	Min.
Expenditure				
1. Input cost for herding				
A. Supplementary feeds				
1) Concentrates (bags)	bags/year	547	1,395	0
Unit price	R.O./50kg-bag	4	5	0
Cost	R.O./year	2,400	6,138	0
2) Hay				
(1) in Summer (bales)	bales/6 months	815	2,340	180
Unit price	R.O./bale	1	1	1
Cost	R.O./6 months	829	2,340	162
(2) in Winter (bales)	bales/6 months	466	1,260	0
Unit price	R.O./bale	1	1	0
Cost	R.O./6 months	471	1,260	0
Hay cost of each herder	R.O./year	1,300	3,060	297
Feed cost of each herder	R.O./year	3,700	9,198	297
B. Raising cost for race camel	R.O./year		2,400	600
C. Livestock purchases	R.O./year		1,000	
2. Farming cost	R.O./year		2,400	250
3. Labor Cost	R.O./year	106	420	0
Input cost of each herder	R.O./year	3,806	15,418	1,147
4. Living expenditure				
1) Electricity	R.O./year	78	420	0
2) Food	R.O./year	1,709	6,000	600
3) Schooling	R.O./year	0	0	0
4) Petrol etc.	R.O./year	476	2,400	0
5) Water	R.O./year	27	204	0
6) Others	R.O./year		240	0
Living expenditure of each herder	R.O./year	2,290	9,012	720
5. Total expenditure	R.O./year	6,096	16,969	2,460

Note: 1) Feeds cost includes the cost of sardines and wheat which were used by one herder of the seventeen surveyed herders.
2) Maximum and minimum values in input cost includes the raising cost of camel for race which four herders of seventeen surveyed herders raise.
3) Maximum values in input cost includes the cost of purchased cows which one herder of seventeen surveyed herders purchased.
4) Maximum and minimum values in input cost includes the cost for cultivation of vegetables, fodder crops and fruits by five herders of seventeen surveyed herders.
5) Average values in input cost do not include the raising cost of race camel, livestock purchases cost and farming cost.

Appendix 8-4 Comparison between the three sub-regions in the Southern Region

A. Principles of agricultural development in the Southern Region

Principles of agricultural development in the Southern Region are as follows;

(1) Development of sustainable agriculture

1) to increase domestic production and to attain self-sufficiency in agricultural produce in the Southern region and in Oman, and
2) to conserve natural resources, especially water resources, and environment.

(2) Creation of new employment opportunities in the area

to be helpful for nomads to settle at one location and to halt migration from rural areas to urban settlements due to generating new incomes and diversifying the farming activities of the farmers in the area.

B. Distribution of the cultivated area in Oman

The population of Dhofar is 189,094 persons, including 34% of expatriates, and constitute 9.4% of the population in Oman. The Governorate of Dhofar accounts for nly about 3% of the total farmed area in Oman, and occupies only 2% of the national area under fruits, 3.5% of the field crops which is dominated by Rhodes grass, 2.5% of all vegetables and 5.5% of other crops.

C. Socio-economic characteristics of each sub-region in the Southern Region

(1) Meteorological characteristics

The Salalah Plain and Jabal in Dhofar have a climate distinct from the rest of the Arabian Peninsula and is affected by the monsoon (khareef) providing precipitation between June to September. Population and crop cultivation in the Southern Region are concentrated mostly in the Salalah Plain.

(2) Family size and number of persons engaged in farming

1) **Salalah**: Family size of the surveyed farmers' households is about 8 in average. Their main jobs are officials, office workers, employer, business man, teacher, police man, fireman, engineer, merchant, etc. The land owner carries out the supervision of the day to day work, while the actual work is performed by expatriate labors. In an average three expatriate labors are employed by each household.

2) **Jabal**: Family size is about 11 in average. Number of family persons engaged in herding is 4, namely 2 men, 1 woman and 1 permanent expatriate labor in average.

3) **Nejd**: Number of households in Nejd is about 200 farmers and about 500 herders, about totaling to 700. Family size of herders' households is about 11 in average. Number of family persons engaged in herding is 4, namely 2 men, 2 women. Hired expatriate labors are hardly found.

(3) Farmer's economy

1) **Salalah**: In most of the households the major source of income is generated through non-agricultural activities. So the household income is more related to the household composition than the agricultural income. Non-farm annual income amounted to about 10,000 OR in average. The annual living expenditure ranges from about 4,000 to 9,000 OR. Most of them consider that they belong to a "middle class" of the country. And their ideal annual income ranged from 4,000 to 8,000 OR.

2) **Jabal**: Herders in Jabal have three sources of income, namely livestock sale of about 2,000 OR, produce sale, which is cow's milk, ghee and animal compost, of about 2,000 OR and off-farm income, which is generated by firqat, civil service, trade and allowance, of about 2,800 OR per year, total of 6,800 OR in average. The annual living expenditure ranges from 520 to 3,900, 2,300 OR in average.

3) **Nejd**: Annual income of herders in Nejd ranges from 2,000 to 14,000 OR, about 4,800 OR in average, which is composed of about 800 OR from livestock sale (goats and camel) and 4,000 OR from non-farm income, such as firqat, civil service, etc.The annual living expenditure ranges from 720 to 9,000 OR, and 2,300 OR in average.

Eight herders of the 17 surveyed herders have private farms and wells, and cultivate vegetables, fodder crops and dates. In 1995, only one herder who produced 2 to 5 tons of water melon, sweet melon, cucumber with a production cost of 2,400 OR earned an income of 3,500 OR. Other herders' farm products were consumed at their home.

(4) Land tenure

1) **Salalah**: There are 4 forms of land tenure in Salalah Plain, namely privately owned and operated by owner, leased land, contract farming and Awqaf. Awqaf belongs to the Ministry of Justice and is distributed among the poor people at a nominal fee. Right of use of this land is passed on their heirs. Most land is privately owned land (about 60% of total land) and about 10% is Awqaf land.

2) **Jabal**: Herders in Jabal do not have private land. Livestock grazes mainly at range land, but range land in Jabal is hardly available from January to June. The present use of range land is over grazing, because rain is less and rain season is not uniform, and number of cattle increases due to poor livestock market to sell.

3) **Nejd**: In Nejd, goats are raised in cages in most cases. Camels are raised in cages or left free. In case of leaving camels free, a herder shifts with camel traveling to range land which is 10 km to 25 km away from home and is in condition of over grazing at present.

Some of herders in Nejd have the private shallow well and farm land, and cultivate vegetable, fodder crops and dates.

(5) Social infrastructure

In general, the social infrastructure facilities and services such as domestic water supply, electricity, health, etc. are not yet developed in Jabal and Nejd. Salalah and Thumrait urban area where these facilities and services are well established and functions as both administrative and commercial center of the Salalah Plain and Nejd region.

D. Agricultural characteristics and constraints of each sub-region in the Southern Region

(1) Type of farming and herding

1) **Salalah**: The farming types in Salalah Plain are mostly diversified farming with vegetables, fruits and livestock, and followed by simplified herding of livestock and simplified farming of vegetables. Two third of the farm-households keep stall-fed animals. About 40% keep dairy cattle, 50% keep sheep and goats, while 17% keep mixed cattle (local and crossbred) and 25% keep chickens.

2) **Jabal**: Herding of livestock use the range land in Jabal. Type of herding livestock is cattle only 56%, followed by cattle and camel, camel only, camel and goats.

3) **Nejd**: There are farmers of about 200 households and herders of about 500 households in Nejd. Type of farming is Rhodes grass cultivation, which is irrigated by groundwater with center pivot system and product is sold as hay to Jabal's herders. Vegetables and dates cultivation used groundwater with traditional irrigation method. Type of herding is camels only and camels and goats. Half of the herders have the private wells and cultivate vegetables, fodder crops and dates, which are mostly consumed at their home.

(2) Land use and area under management

1) **Salalah**: 3,543 ha are put to agriculture use, out of which around 75% (2,676 ha) is used for cultivation of various crops. Four large farms, namely the Royal Farm, the Dhofar Cattlefeed Company, the Livestock Research Farm and one private farm, own 41% of total agricultural land, while 90.4% of farms are of less than 4.2 ha in size and own only 40.8% of the total area. As around 60% of operated land is put under perennial fruit trees and grasses, and only 40% is available for cultivation. Mostly vegetables are grown in these lands. Among the vegetables, tomatoes are most popular, followed by pepper and chilies. Tomatoes can be called as the main vegetable crop of the area and is being supplied to other parts of Oman.

2) **Jabal**: Livestock grazes mainly at range land from July to December. In other seasons, livestock is fed with the supplementary feeds, such as purchased hay, sardines,

concentrates, etc. The present use of range land is over grazing, because rain is less and rain season is not uniform, and number of livestock increases due to poor livestock market.

3) **Nejd**: Sizes of fodder cultivation farms by center pivot system are ranged from 30 ha to 400 ha per farm. Average size of the private farms that cultivated vegetables and dates with traditional irrigation method is 5.7 ha.On the other hand, herders raise whole goats and half of camels in cages and feed them with supplementary feeds. Half of camels are left free and herders shift with camel traveling to range land which is 25 km to 10 km away from home and is in condition of over grazing at present.

(3) Irrigation

1) **Salalah**: Irrigation water to the farms is supplied by rain in khareef and groundwater. The four large farms, owned 41% of total agricultural land, are irrigated with the modernized irrigation systems and the other private farms are mostly irrigated with traditional (furrow) irrigation.

In Salalah Plain Government policies of price support and subsidies to the livestock sector have induced changes in the land use pattern. These policies have encouraged the expansion of area under banana and grasses which have high water requirements thus further deteriorating the aquifer water balance. The FAO's survey has shown that the area has attained a critical limit of salinity because only 30% of the area has safe water quality and 50% is in the critical zone of 3 to 7 ms/cm.

2) **Jabal**: Vegetation in range land is supplied water by rain in khareef. Recently, rainfall is less and the rainy season is not uniform, and then growth of vegetation have decreased very deeply in comparison with 10 years ago.

3) **Nejd**: Irrigation water to the farms is supplied by fossil groundwater. Farms of Rhodes grass cultivation have deep wells and irrigate with good quality of Aquifer C water by center pivot system. The other farms have shallow well or flowing water and irrigate with poor quality of Aquifer A water by the traditional irrigation method.

(4) Livestock raising

(4)-1 Number of livestock

1) **Salalah**: Number of cattle, sheep, goats and chickens per household in the survey ranged from 8 to 67 heads of cattle, 22 to 85 of sheep, 8 to 120 of goats and 50 to 3,000 of chickens, respectively.

2) **Jabal**: Number of cattle per household in the survey ranged from 151 to 40 heads.

3) **Nejd**: Number of goats and camels per household in the survey ranged from 12 to 153

heads of goats, 6 to 71 heads of camels, respectively.

(4)-2 Feeding

1) **Salalah**: Most of the farmers who raise livestock cultivate Rhodes grass but do not have enough of roughage. Therefore, they purchase some green fodder and hay, besides sardines and concentrates. The large farms in Salalah produce hay and sell to Jabal's herders.

2) **Jabal**: Quantity of hay for raising cattle is very short in Jabal and the whole herders purchase hay produced at Salalah, Nejd and northern area of Oman, besides sardines and concentrates. Amount of fed hay is the highest in April to June.

3) **Nejd**: Most of the herders purchase roughage and concentrates for goats and camels. Amount of fed hay is the highest in summer (April to September). Therefore, the demand for hay is the highest and the unit price of hay is the highest in summer. Purchased hay is mostly produced at Nejd and PDO farm in Marmul.

(4)-3 Manure production

Farm yard manure is extensively used in Salalah Plain. The Jabal remains as the main source of farm yard manure. Manure production is one of the sources of generating incomes for the Jabal's herders.

(5) Agricultural incomes and costs

1) **Salalah**: Banana is the most profitable crop, followed by coconut and tomatoes, while other crops are not profitable and are mainly cultivated for home consumption. The dairy enterprise is profitable due to high price of milk. Sheep and goats are not profitable and are mainly kept for home consumption.

2) **Jabal**: Income from herding are composed of livestock sale and sale of livestock produce, such as milk, ghee and manure. However, herder's finances are in the deficit in all the surveyed herders, because livestock and livestock produce marketing are poor and roughage is in short due to poor vegetation of range land and increase of livestock.

3) **Nejd**: Income from herding is only 16% of total household income, including off-farm income. It seems that balances in agriculture of most of farmers and herders are in the deficit, except the large farms of Rhodes grass cultivation with the modernized irrigation system.

(6) Constraints of farming and herding

The objective of farming is primarily to keep ties with the past. The ownership of farm land and livestock raises the status of the family in the community. Farmers and herders have no intention of selling products by nature. There is a gap between Government policy

to increase agricultural production and the objectives of farmers. Agriculture in these regions would be not be materialized without subsidies and services of Government.

(6)-1 Salalah:

-1 The soils of Salalah Plain are highly calcareous and low fertility. Deficiencies in micronutrients affect nearly all crops.

-2 The area has attained a critical limit of salinity because only 30% of the area has safe water quality and 50% is in the critical zone of 3 to 7 ms/c. This is caused by deteriorating aquifer water balance due to the expansion of area under banana and grasses which have high water requirements.

-3 In agricultural production, services and marketing, nearly all the labor forces are expatriates who are often involved in the management of farm and are more interested in immediate profit and therefore little motivated for long term conservation of natural resources. Besides, expatriates are often not familiar with agriculture and extension services do not function properly due to the problem of communications.

-4 Marketing of agricultural produce, especially vegetable, is a major problem for farmers. In peak production periods farmers are often obliged to sell their production at very low prices. Storage facilities are inappropriate and losses are high. PAMAP is trying to improve the situation but faces problems of excess supply alternating with periods of shortage.

-5 At present the milk herd in Salalah produces more than the demand for fresh milk especially during khareef season. Fresh milk in excess of the family needs is partly sold at the farm gate to regular buyers and partly fed to young animals due to lack of marketing facilities. The marketing of milk seems to be a serious constraint since no milk collection system exists.

Sales of live animals are rare and mainly occur during religious festivals and wedding occasions normally held during khareef season.,

(6)-2 Jabal:

Marketing of livestock and its produce is poor. Therefore, the number of livestock increases inevitably by multiplier effect of herders' intention and poor marketing. As a result of increase of livestock, range land deterioration has been induced by overgrazing and lower rainfall in khareef lately, and the cost of supplementary feed in herding households, especially purchased hay, has increased. Herders' management are pressured by these feeding costs.

(6)-3 Nejd:

-1 The major constraint of agriculture in Nejd is water for farming and herding, which is only supplied by fossil groundwater. Intentional use of water under consideration to conserve water resources is required and reckless agricultural development should not be done.

-2 Social infrastructure, such as electricity, road for transportation, storage facilities of products, etc., is poor. And living standard of farmers is low, therefore, farmers could not invest in farming and herding. In this situation farmers could not employ the expatriates.

-3 Farmers can not receive the Government services, such as extension services, veterinary services, chemical spraying and tractor hire services, etc.

-4 Marketing of livestock and its produce is poor. Therefore, the number of livestock increases inevitably by multiplier effect of herders' intention and poor marketing.

Table A-8.5.1 Survey Results of small farms in the Study Area

No.	Area	Name of Farmer / Company	Area fodan	Farming Period	No. of Labours	Livestock	Water Source	Irrigation System	Soil		Irrigation Water		Farming Conditions
									pH (1:2.5)	EC (1:5), mS/cm	pH	EC, mS/cm	
1.	Hailat-Al-Rakah	Farag Mohd. Ba-Makalif	25	6 years	1	-	Deep well	traditional	8.3 7.9 8.0	0.190 0.265 0.256	8.1	1.70	Dates, Rhodes grass, Tomato, Cucumber, chilli, lemon (Self use only)
2.	Hailat-Al-Rakah	Mussallam Rahabal Gidad	10	12 years	3	camels-2	Deep well	traditional	8.3 8.5	0.376 0.301	8.2	2.50	Dates, S.Potato, Tomato, Egg plant, Onion, potato (self consumption)
3.	Hailat-Al-Rakah	Salim Aidhad Mohd. Gidad	100	10 years	No	No	Deep well	traditional	8.2 8.3 8.1	0.315 0.423 0.216	8.1	2.20	Squash, S.Potato, Tomato, Egg plant, Onion, Carrot (Sold in Salalah & self use)
4.	Hailat-Al-Rakah	Al-Abd Said Saad Gidad		10 years	1	No	Deep well	traditional	8.5 8.1 8.5	0.514 1.850 0.505	7.9	4.70	S.Melon, S.Potato, Tomato, Egg plant, Onion, Dates (Sold in Salalah & self use)
5.	Hailat-Al-Rakah	Salem Suhail Wassit Hazar	35	13 years	1	No	Deep well	traditional	8.5 8.7 8.3	0.153 0.175 0.233	8.0	1.90	Dates, Lemon, S.melon, w.melon, grapes, Rhodes grass (self consumption)
6.	Hailat-Al-Rakah	Salim Suhail Salem Al-Shasaei	7	10 years	1	No	Deep well	traditional	8.2 8.2 8.4	5.171 10.950 1.460	7.9	2.90	Dates,Tomato, Onion, Carrot Egg plant, Cucumber,S.Potato (Sold in Salalah)
7.	Hailat-Al-Rakah	Mubkhot Ali Said	200	8 years	1	camel-20 goat-50	Deep well	Center pivot & traditional	8.2 8.3 8.1	2.170 0.594 2.660	8.0	2.90	Rhodes grass Dates (Sold in Salalah)
8.	Hailat-Al-Rakah	Salem Said Abdullah Al-Shasaei	100	6 years	1	No	freely flowing	traditional	8.3 8.1 7.9	0.143 0.154 0.123	8.1	1.80	Squash, Cucumber, Tomato, Egg plant, Onion, Pepper,melon (Sold in Salalah)
9.	Shisr	Bakit Abdullah Salem Missan	10	17 years	1	sheep-20 camels-10	freely flowing	traditional	8.3 7.9 8.0	0.190 0.265 0.256	8.1	1.70	Dates, Rhodes grass, Tomato, Cucumber, chilli, lemon (Self use only)
10.	Shisr	Said Mussalam Salem Missan	100	15 years	5	sheep-30 camels-50	freely flowing	traditional	8.1 8.2 8.0	0.244 0.176 0.200	7.8	1.40	Dates, Rhodes grass, Tomato, Egg plant, Squash, lemon (marketting problems)
11.	Shisr	Abdullah Salem Missan	30	25 years	1	sheep-40 camels-150	freely flowing	traditional	8.4 8.4 8.3	0.123 0.118 0.116	8.1	1.70	Dates, Squash, Tomato, (Self use only)
12.	Shisr	Said Hamad Hotti Al-Mashally	100	10 years	3	sheep-60 camels-200	freely flowing	traditional	7.7 7.7 8.2	0.417 0.203 0.149	8.4	1.70	Dates, Tomato, Squash
13.	Shisr	Mohd. Saleh Mod. Missan	30	25 years	1	sheep-60 camels-80	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Tomato, Egg plant, Squash, lemon (marketting problems)
14.	Shisr	Mohd. Bakhit Missan	80	20 years	2	camels-120	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Tomato, Egg plant, Cucumber (marketting problems)

Table A-8.5.1 Survey Results of small farms in the Study Area

No.	Area	Name of Farmer / Company	Area fedan	Farming Period	No. of Labours	Livestock	Water Source	Irrigation System	Soil		Irrigation Water		Farming Conditions
									pH (1:2.5)	EC (1:5), mS/cm	pH	EC, mS/cm	
15.	Shisr	Mabrook Ahmed Saley Missan	100	25 years	4	sheep-60 camels-80	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Tomato, Egg plant, Cucumber, Lemon (Poor infrastructure)
16.	Shisr	Salem Mohd. Saleh Missan	100	25 years	3	sheep-70 camels-150	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Tomato, Egg plant, Lemon (Poor infrastructure)
17.	Shasr	Al-Gannah Musallam Missan	30	25 years	2	sheep-120	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, water melon, Tomato, Egg plant, Lemon, Squash (Poor infrastructure)
18.	Shasr	Mohd. Salem Mohd. Missan	20	25 years	1	sheep-10 camels-20	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, s.melon Egg plant, Lemon, w.melon (Poor infrastructure)
19.	Shisr	Musallam Said Missan	30	25 years	1	sheep-10 camels-30	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Cucumber Egg plant, Lemon (Poor infrastructure)
20.	Shasr	Ahmed Saleh Mohd. Missan	60	25 years	1	sheep-200 camels-90	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Tomato, Egg plant, Squash (Poor infrastructure)
21.	Shasr	Musallam Abdullah Missan	100	25 years	4	sheep-50 camels-100	freely flowing	traditional	8.0 8.0 8.2	0.152 0.144 0.122	8.1	1.70	Dates, Rhodes grass, Egg plant, Cucumber, w.melon (Poor infrastructure)
22.	Dawkah	Mohd. Said Mayah		21 years	2	goat-50	freely flowing	traditional	8.0 8.1	5.170 11.950	7.9	2.00	Dates, water melon, Tomato, Egg plant, Lemon, Squash (marketting problems)
23.	Thumrait	Mubarak Houl Missan	20	13 years	1	No	freely flowing	traditional	8.2	0.460	7.9	2.00	Dates (Sold in Salalah)
24.	Rawyah	Mohd. Ahmed Salim Al-Shasaei	25	7 years	2	No	freely flowing	traditional	8.2 8.4 8.0	2.170 0.594 2.660	8.1	2.80	Dates, Onion, Cucumber S.melon, squash, w.melon (Sold in Salalah)

Table A-8.5.2 Survey Result of Big Farms in the Study Area

Area / Farm ID	Name of Farmer / Company	No.of Labors	Irrigation Type	C.P. ID No.	No. of Arms	Area (ha)	Start year	Water Application	(mm/d)	Well ID No.	Present Condition: Generals	Soil pH (1:2.5)	Soil EC(1:5) mS/cm	Water pH	Water EC mS/cm	Farming Conditions	Irrigators' Location
Hanfeet East																	
1	Al Thumra Farm	5	C.P.	HE-1	7	30	'93 Early	1 Well 700GPM/17hr	10.8	210/893	1/4 area under backfilling Not irrigation at outend arm Water shortage recently	8.40 8.00	0.549 0.988	7.80	1.83	Poor grass growth	18°00.21 N 54°03.50 E
				HE-2	0	0					Under planning in vicinity Scale is not obvious					Not started yet	???
2	Al Watheeka			HE-3	0	0					Under drilling Scale is not obvious	8.20	0.450			Not started yet	18°00.19 N 54°04.38 E
3	Ali Mohd (Al Ez Farm)	2	C.P.	HE-4	6	30	'95 Mid	1 Well 700GPM/17hr	10.8	210/974	Original 7arms, one deleted because of recent water shortage Well provided by MWR	8.50 8.10	0.469 0.500	8.40	2.39	Moderate grass growth	17°53.56 N 54°00.52 E
Hanfeet West																	
4	Al Ez Farm	10+	C.P.	HW-1	6	29	'95 Mid	1 Well 800GP/14hr	10.5	210/890		8.10 8.10	0.530 0.520	8.10	2.69	9 harvests/year Poor alfalfa growth	17°52.59 N 53°57.56 E
			C.P.	HW-2	7	40	'95 Mid	1 Well 900GP/16hr	9.8	213/798				7.80	2.4		17°52.01 N 53°58.07 E
			C.P.	HW-3	7	41	'95 Mid	1 Well 1000GP/16hr	10.6	210/890	Present WL at -100m from GL Hence stopped irrigation recently			7.70	2.48		17°52.59 N 53°57.56 E
			C.P.	HW-4	6	29	'95 Mid	1 Well			Original 7arms, one deleted because of recent water shortage			STOPPED / Gen.set under repair			17°52.31 N 53°57.57 E
5	Oman Gulf Co.		C.P.	HW-5	6	29	'94	900GPM/12hr	10.2	Non-No.		8.50 8.40	0.331 0.229	8.20	2.09		17°53.58 N 53°57.08 E
			C.P.	HW-6	8	50	'94	1 Well		213/417							17°54.26 N 53°57.34 E
Dawkah																	
6	Oman Gulf Co.	20	C.P.	DK-1	8	53	'86	1 Well 1000GP/20hr	10.3		WL recovers in 4hrs rest after 18 hrs irrigation, available 1000GPM Drainage potential poor, pounded.	8.30 8.40	1.700 1.174	7.90	1.66	Salinity problem Water logging	18°11.39 N 54°02.49 E
			C.P.	DK-2	7	40	'86	750GPM/20hr	10.2		750GPM by boosting from same well above						18°12.19 N 54°02.49 E
			~~C.P.~~	DK-3	0	30	'90				Draught then demolished CP'95						18°12.19 N 54°03.15 E
				DK-4	0						Under developing exis. well to deeper. Foundation and parts on site already	8.90	0.152	8.10	1.71		18°45.00 N 54°02.00 E
New Hilat Arrakah																	
7	Al Beed Farm	8	C.P.	HR-1	6	30	'93							7.80	1.54		18°21.37 N 54°01.16 E
			C.P.	HR-2	7.5	46	'96				Started 7-month before			7.70	1.61		18°21.37 N 54°00.42 E
8	Oman Gulf Co.	20	C.P.	HR-13	9	67	'94	1000GP/18hr	7.3								18°20.38 N 53°59.34 E
			C.P.	HR-3	6	30	'91	800GPM/18hr	13.1	210/824				7.70	1.51		18°21.25 N 54°00.17 E
			C.P.	HR-4	6	30	'95	800GPM/18hr	13.1	210/826				7.60	1.53		18°21.02 N 54°00.17 E
9	Al-Ez	11	C.P.	HR-5	8	51	'92	1000GPM/20hr	10.7	210/835				7.90	1.42		18°21.33 N 53°58.43 E
			C.P.	HR-6	8	51	'96	1000GPM/20hr	10.7	210/837	Started 8-month before			7.90	1.36		18°21.02 N 53°58.43 E
10	Bahit Bahit	2	C.P.	HR-7	6	30	'96	900GPM/18hr	14.7	210/828	Started 6-month before			7.80	1.41		18°21.01 N 53°59.52 E
11	Ba Muhallah Co.	3	C.P.	HR-8	5	20	'91	300m Well				8.30 8.20	0.267 0.833	8.70	1.65	Good grass growth & vegetables(melon)	18°23.48 N 53°55.49 E
			~~C.P.~~	HR-9	5	20	'94 Early				Only 2months worked and stopped						18°23.48 N 53°59.34 E
12	Mubalak Saed		~~C.P.~~	HR-10	5	20	'93	7months only & removed									18°21.41 N 53°55.25 E
			~~C.P.~~	HR-11	5	20		Shift'g to Dawkah									18°21.01 N 53°56.38 E
			~~C.P.~~	HR-12	5	20										Leave grass without irrigation Going to be repaired	18°20.05 N 53°58.08 E
13	NARS		C.P.	NJD-A	6	30	'94 Sep.										
			L.M.	NJD-B		18	'94 Sep.				June '95 stopped irrigation						
Shasr																	
14	Ubar Agriculture	7	C.P.	SH-1	8	51	'96 Jan	1 Well 1300GPM/18hr	12.5			9.10 9.30	0.177 0.490	7.90	1.75	Many empty patches	18°11.27 N 53°41.53 E
			C.P.	SH-2	8	51	'96 Apr.	1 Well 1300GPM/18hr	12.5								18°11.55 N 53°42.10 E
			Total Area			986 ha (Simple accumulation)											
						826 ha (Present Irrigated Area)											

Note : C.P.; Center Pivot ~~C.P.~~ Center Pivot already demolished or abandoned
EC Value At 35 Celestial

Table A-8.5.3 Assessment of soil pH and EC for the farms and various locations of the Study Area

No.	Area	Name of Farm/ Sampling Location	pH (1:2.5)		EC (1:5), mS/cm	
			Sample 1	Sample 2	Sample 1	Sample 2
	Center Pivot Farms					
1.	Hanfit East	Al-Thumra Co.	8.4	8.0	0.549	0.988
2.	Hanfit East	Al-Wathika (Construction, just started)	8.2		0.430	
3.	Hanfit East	Aleez Company	8.5	8.1	0.469	0.500
4.	Hanfit West	Aleez Company	8.1	8.1	0.530	0.520
5.	Hanfit West	Oman Gulf Co.	8.5	8.4	0.331	0.229
6.	Wadi Bani Khwatar	Musallam Suhail (Village Chief)	8.5	8.5	1.747	1.130
7.	Dawkah	Oman Gulf Co.	8.3	8.4	1.700	1.174
8.	Dawkah	Oman Gulf Co.(Under construction)	8.9		0.152	
9.	Shasr	Ubar Agriculture	9.1	9.3	0.177	0.490
10.	Hailat-Al- Rakah	Ba Muhallah Co	8.8	8.2	0.267	0.833
11.	Hailat-Al- Rakah	Mubkhot Ali Said	8.2	8.1	2.170	2.660
12.	Hailat-Al- Rakah	Mohd. Salem Kamedish	8.1	8.1	1.713	3.370
13.	Hailat-Al- Rakah	Farah Al-Somali (Center pivot abondoned)	8.5		2.140	
14.	Hailat-Al- Rakah (N)	Albeet farm	8.7	8.9	0.567	0.437
15.	Hailat-Al- Rakah (N)	Oman Gulf Co.	8.9		0.360	
16.	Hailat-Al- Rakah (N)	Bakhit Bakhit	8.9		0.275	
17.	Hailat-Al- Rakah (N)	Aleez Company	9.0		0.375	
	Small Farms					
1.	Hailat-Al- Rakah	Farag Mohd. Ba-Makalif	7.9	8.0	0.265	0.256
2.	Hailat-Al- Rakah	Mussallam Rahabal Gidad	8.3	8.5	0.376	0.301
3.	Hailat-Al- Rakah	Salim Aidhad Mohd. Gidad	8.3	8.2	0.423	0.315
4.	Hailat-Al- Rakah	Al-Abd Said Saad Gidad	8.5	8.5	0.514	0.505
5.	Hailat-Al- Rakah	Salem Suhail Wassit Hazar	8.7	8.5	0.175	0.153
6.	Hailat-Al- Rakah	Salim Suhail Salem Al-Shasaei	8.2	8.4	1.460	5.171
7.	Hailat-Al- Rakah	Salem Said Abdullah Al-Shasaei	8.1	8.3	0.154	0.143
8.	Hailat-Al- Rakah	Mubarak Houl Missan	8.2		0.460	
9.	Hailat-Al- Rakah	Mohd. Ahmed Salim Al-Shasaei	8.4	8.2	2.170	2.660
10.	Shisr	Bakit Abdullah Salem Missan	7.9	8.0	0.265	0.256
11.	Shisr	Said Mussalam Salem Missan	8.2	8.0	0.176	0.200
12.	Shisr	Abdullah Salem Missan	8.4	8.3	0.118	0.116
13.	Shisr	Said Hamad Hotti Al-Mashally	7.7	8.2	0.203	0.149
14.	Shisr	Mohammed Missan	8.0	8.2	0.144	0.122
15.	Dawkah	Mohd. Said Mayah	8.0	8.1	5.170	11.950
	Other Areas					
1.	Wadi Dawkah	40km from Shisr towards Dawkah	9.3	9.2	0.096	0.135
2.	Wadi Quitbit	18° 02' 42" N, 54° 15' 06" E	9.4		0.100	
3.	Wadi Quitbit	18° 05' 41" N, 54° 22' 51" E	9.4	9.4	0.085	0.076
4.	Wadi Quitbit	18° 18' 24" N, 54° 22' 19" E	9.5	9.5	0.070	0.074
5.	Hailat-Al-Rakah	14km North of NARS 9km east	8.5	8.7	0.275	0.353
6.	Wadi Bani Khwatar	18km North of Dawka meteo stn.	8.2	8.2	2.190	3.380
7.	Dawkah	Dawkah (13.5km off the road)	8.9	8.7	0.183	0.261
8.	Hanfit West	37km south of NARS; 8km west	9.1	9.0	0.085	0.123
9.	Hanfit West	2.8km south of the location 1	8.9		0.173	
10.	Hanfit West	8.5km from location 1 to Shisr	9.0	9.1	0.111	0.122
11.	Hanfit West	15km from location 3 to Shisr	9.0	9.1	0.116	0.104
12.	Shisr	3.5km from Shasr road	9.1		0.126	
13.	Shisr to Thumrait	17° 42' 11" N, 53° 47' 14" E	9.0		0.102	
14.	Wadi Quitbit	18° 11' 45" N, 54° 32' 45" E	8.7	8.7	0.336	0.580
15.	Hanfit East	JICA well location	9.0		0.111	0.111
16.	Hanfit East	18° 04' 08" N, 54° 10' 01" E	8.3	8.3	0.906	1.204
17.	Wadi Mokhawrim	18° 34' 49" N, 54° 14' 12" E	8.4		0.261	
18.	Wadi Mokhawrim	18° 33' 13" N, 54° 19' 24" E	8.1	8.8	0.679	0.107
19.	Wadi Mokhawrim	18° 38' 45" N, 54° 22' 50" E	8.4		0.327	
20.	Hailat-Al-Rakah	18° 21' 45" N, 53° 53' 20" E	8.5		0.701	0.701
21.	Hailat-Al-Rakah	18° 25' 14" N, 53° 46' 27" E	8.5	8.4	2.020	2.860
22.	Hailat-Al-Rakah	18° 17' 06" N, 53° 54' 07" E	8.5	8.4	1.053	0.493
23.	Hailat-Al-Rakah	18° 14' 20" N, 53° 53' 55" E	8.1	8.1	1.713	3.370
24.	Hailat-Al-Rakah	18° 22' 05" N, 53° 55' 49" E	8.5		2.140	
25.	Hailat-Al-Rakah	18° 16' 08" N, 54° 01' 15" E	8.7	8.5	0.099	0.241

Table A-8.5.4 MWR Monitoring Wells in the Study Area

SITE ID		UTM Grid E	UTM Grid N	Coordinate Long.	Coordinate Lat.	WELL DEPTH (m)	MP. ELEV. (amsl)	Aquifer	EC μS/cm	W.L from MP (m)	DATE (1996)	W.L from MP (m)	DATE (before 1994)	W.L. (Elevation) (1996)	W.L. (Elevation) (before 94)	Drawdown (m) (before 94-96)
AF825206 AA	JICA6	185000	2022550	540118	181607	295.0	(280)	C	1620	23.56	14-Oct	7.56	Aug-94	256.4	272.4	-16.0
AF827408 AA	JICA5	187000	2024800	540223	181724	300.0	(275)	C	1643	23.00	14-Oct	3.82	Aug-94	252.0	271.2	-19.2
AF828801 AA	NJD1	188000	2028100	540250	181825	402.3	272.2	C	1600	21.93	21-Oct	1.91	Aug-94	250.3	270.3	-20.0
AF828801 CA	NJD3	188188	2025944	540302	181801	350.0	272.2	C	1600	22.00	21-Oct	2.77	Aug-94	250.2	269.4	-19.2
AF829201 AA	H.Raqah	189000	2022100	540328	181559	269.0	(280)	C		25.96	21-Oct	10.48	Aug-94	254.0	269.5	-15.5
AF920700 AA	Km.79 BH	190000	2027000	540401	181837	269.0	(275)	A+B	2750	Welded Cap		44.96	Mar-92	-----	230.0	----
BE050838 AA	W.Ribkut	200300	1960000	541032	174146	330.0	456.0	C	3480	161.94	13-Oct	159	Sep-93	294.1	297.0	-2.9
BE094486 AA	Ribkut	204800	1994600	541301	180059	553.0	(340)	D	1850	46.93	13-Oct	46.43	Jul-94	293.1	293.6	-0.5
BF000000 AA	W.Ribkut	200058	2000074	541002	180408	335.0	336.8	C	2380	66.78	13-Oct	63.3	Jul-93	270.0	273.5	-3.5
BF040020 AA	W.Baharawn	200129	2040052	540943	182546	336.0	253.9	C	1775	5.07	12-Oct	(3.60)	Jul-93	248.9	257.5	-8.7
BF040020 BA	W.Baharawn	200129	2040052	540943	182546	215.0	253.5	B	3360	26.23	12-Oct	29.1	Oct-93	227.2	224.4	2.9
BF080077 AA	B.Khawtar	200741	2080773	540942	184749	----	(195)	C	1286	flowing	12-Oct	-----		242.0	----	(0.0)
BF263460 AA	Makhawrun	223662	2063643	542245	183857	400.0	225.0	(B)+C	1620	flowing	22-Oct	(0.50)	Nov-88	225<	225.5	(0.0)
BF410641 AA	W.Qitbit South	240406	2013593	543249	181145	287.0	(300)	B+C	1680	36.11	13-Oct	35.8	Aug-94	263.9	264.2	-0.3
BF470809 AA	Qitbit	240002	2078993	543203	184706	----	(205)	(C)	----	f:4.95psi(+3.5)	20-Aug	-----		208.5	----	----
BF840101 AA	Ranooha	280000	2040000	545501	182653	316.0	(240)	C	2920	40.39	26-Sep	42.1	Oct-93	199.6	197.9	1.7
BG015793 AA	R.Garum	205930	2117300	541222	190742	----	(170)	C	----	f:93.18psi(+62.2)	20-Aug	-----		235.2	----	----
BG117784 AA	B.Khawtar	217800	2117400	541911	190743	95.0	142.0	A	2142	35.59	19-Sep	35.38	Nov-88	106.4	106.6	-0.2
BG117784 BA	B.Khawtar	217800	2117400	541911	190743	95.0	143.0	A	----	35.42	19-Sep	35.32	Nov-88	107.6	107.7	-0.1
BG203908 AA	Km.165 BH	223000	2109000	542211	190355	347.0	150.0	B+C	2000	unconfirmed		(43.5?)	Jan-91	----	----	----
BG317999 AA	Qitbit	237900	2119900	543040	190917	----	(150)	C	----	f:51.4psi(+36.0)	20-Aug	-----		186.0	----	----
YA715978 AA	Shisr	776209	2019918	533642	181504	250.0	290.0	(B)+C	1365	0.11	30-Oct	(0.14)	May-85	289.9	290.1	-0.3
YA933809 AA	Shisr	793881	2039236	534627	182513	333.0	260.0	C	1425	flowing 12 l/m?	14-Oct	f(EC1425)	Sep-93	260<	260<	(0.0)
YV760834 AA	W.Rana	770300	1968400	533258	174710	412.0	400.0	C	1260	27.72	21-Sep	26.94	Aug-94	372.3	373.1	-0.8
YV892605 AA	Bin Nawtash	782000	1996500	533951	180245	106.5	325.0	A+(B)	1500	f:6psi(+4.2)	13-Oct	(3.00)	Apr-85	329.2	328.0	----
YV892605 BA	Bin Nawtash	782000	1996900	533951	180235	106.0	334.0	(B)	----	flowing	29-Oct	-----		-----	----	----
YV892605 CA	Bin Nawtash	782000	1996500	533951	180245	110.0	(325)	B	1560	unconfirmed		(5.63)	Mar-86	----	330.6	----
YV892605 DA	Bin Nawtash	782000	1996900	533951	180233	60.0	(325)	A	1300	Capped		36.09	Mar-86	-----	288.9	----
YV955965 AA	W.Haweef BH3	795500	1959500	534715	174212	323.0	442.2	C	2480	98.18	13-Oct	98.2	Oct-93	344.1	344.0	0.0
YV995858 AA	Shisr	795193	1999272	534729	180328	267.0	328.1	C	1440	56.98	13-Oct	29.5	Aug-93	271.2	298.6	-27.5
ZA035301 AA	PAWR Dewqah	805000	2033100	535320	182148	300.0	257.9	(B)+C	1600	9.39	14-Oct	(7.14)	Feb-91	248.5	265.0	-16.5
ZA163805 AA	Daukah	813020	2068540	535754	184101	350.0	198.6	C	1600	artesian (closed valve)		(35.75)	Mar-92	198.6<	234.4	-----
ZA163805 BA	Daukah	813000	2068500	535754	184101	350.0	198.7	C	1650	f:33psi(+23.1)	12-Oct	(31.67)	Sep-92	221.8	230.4	-8.6
ZA163805 CA	Daukah	813000	2068500	535754	184101	280.0	198.7	B+C	2610	f:50psi(+35.0)	12-Oct	(37.71)	Oct-92	233.7	236.4	-2.7
ZA163805 DA	Daukah	813000	2068500	535754	184101	350.0	198.9	C	1681	f:36psi(+25.2)	12-Oct	(30.32)	Oct-92	223.9	229.2	-5.3
ZV099779 AA	Hanfeet	809700	1997900	535513	180219	300.0	321.2	C	1550	51.95	13-Oct	28.73	Aug-94	269.2	292.4	-23.2
ZV099779 BA	Hanfeet	809700	1997900	535513	180219	265.0	321.5	C	1323	52.38	13-Oct	29.02	Aug-94	269.2	292.5	-23.4
ZV099779 CA	Hanfeet	809700	1997900	535513	180219	270.0	320.0	C	1540	53.01	13-Oct	29.65	Aug-94	267.0	290.4	-23.4
ZV182823 AA	Hanfeet	812200	1988300	535652	175741	285.0	336.5	C	2450	69.73	13-Oct	39.31	Aug-94	266.8	297.2	-30.4
ZV182823 BA	Hanfeet	812200	1988300	535652	175741	189.0	336.7	B	4000	60.45	13-Oct	60.54	Aug-94	276.2	276.1	0.1
ZV182824 AA	Hanfeet	812200	1988400	535652	175742	290.0	336.3	C	3000	69.50	13-Oct	39.12	Aug-94	266.8	297.2	-30.4
ZV193035 AA	Hanfeet	813300	1990500	535730	175849	200.0	329.0	B	3860	56.66	13-Oct	56.92	Aug-94	272.3	272.1	0.3
ZV193035 BA	Hanfeet	813300	1990500	535730	175849	286.0	329.0	C	2300	62.25	13-Oct	32.05	Aug-94	266.8	297.0	-30.2
ZV193035 CA	Hanfeet	813300	1990500	535730	175849	285.0	329.0	C	----	62.30	13-Oct	31.95	Aug-94	266.7	297.1	-30.4
ZV193045 AA	Hanfeet	813400	1990500	535730	175848	286.0	329.1	C	2500	62.10	13-Oct	31.64	Jun-94	267.0	297.4	-30.5

ELEV. in brackets ; estimated W.L in brackets = G.L+ source : MWR